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THE AERODYNAMIC CHARACTERISTICS OF THE FREE FLIGHT DEMONSTRATIO--ETC(U)
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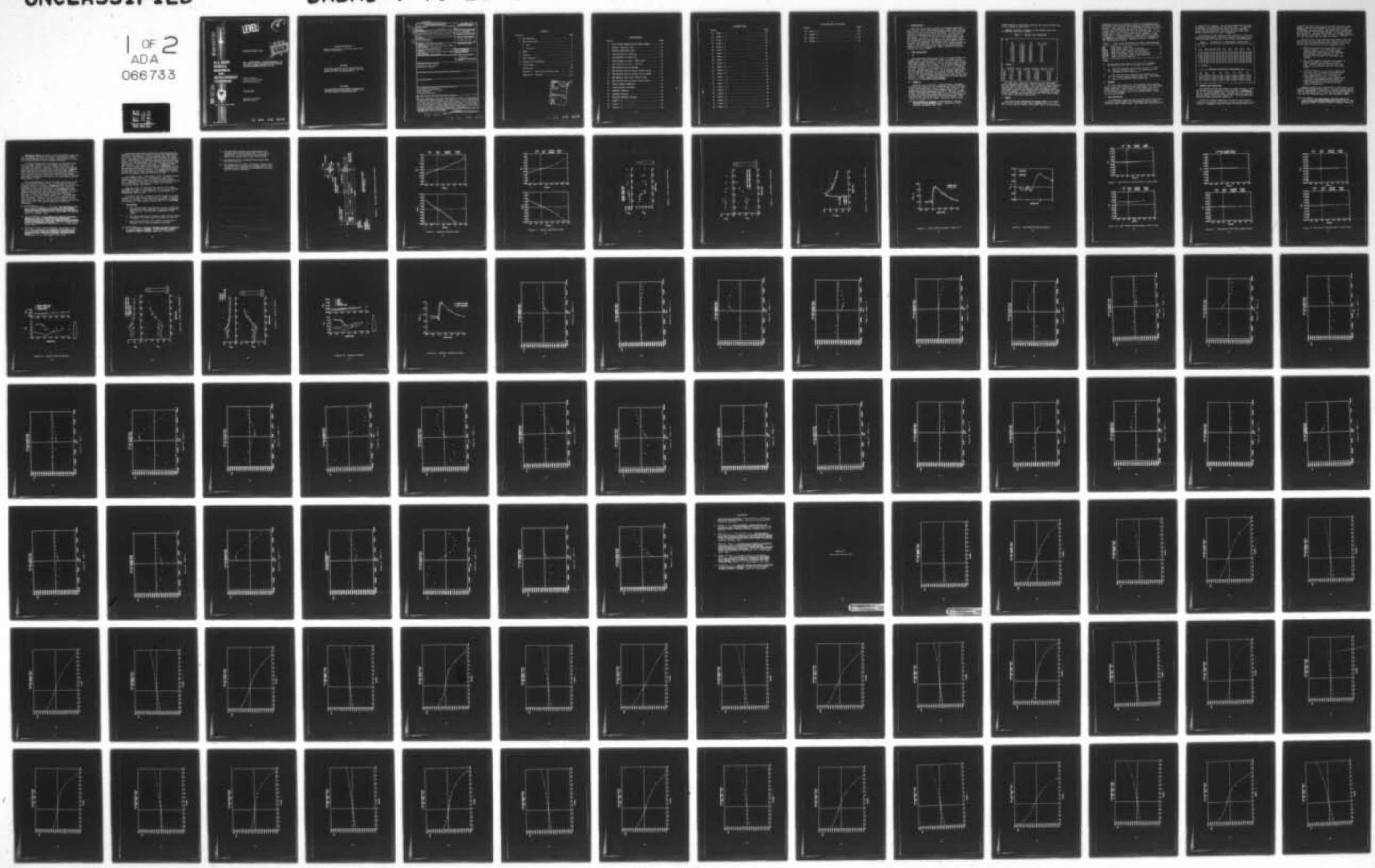

U.S. ARMY MISSILE RESEARCH AND DEVELOPMENT COMMAND

TECHNICAL REPORT T-79-26

THE AERODYNAMIC CHARACTERISTICS OF THE FREE FLIGHT DEMONSTRATION ROCKET AT MACH NUMBERS FROM 0.4 TO 3.0

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22 January 1979

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The Free Flight Rocket Technology Program generated a need for the Free Flight Demonstration Rocket test vehicle. This vehicle is to be used to determine the success of past efforts to improve free rocket accuracy. It will also be used as a data-gathering test bed to evaluate future improvements. As part of the Free Flight Demonstration Rocket design validation, a series of two wind tunnel tests was conducted at the Arnold Engineering Development Center to verify the predicted areodynamic coefficients of the selected configuration.

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ILLUSTRATIONS

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1. INTRODUCTION

The Free Flight Rocket Technology Program generated a need for the Free Flight Demonstration Rocket test vehicle. This vehicle is to be used to determine the success of past efforts to improve free rocket accuracy. It will also be used as a data-gathering test bed to evaluate future improvements. As part of the Free Flight Demonstration Rocket design validation, a series of two wind tunnel tests was conducted at the Arnold Engineering Development Center to verify the predicted areodynamic coefficients of the selected configuration. The effect of an underexpanded jet plume on the stability of the Free Flight Demonstration Rocket was also investigated. These results will be published in a later report.

2. TEST FACILITIES

A. 4T

The Aerodynamic Wind Tunnel (4T) is a closed-loop, continuous-flow, variable-density tunnel in which the Mach number can be varied from 0.1 to 1.3 and can be set at discrete Mach numbers of 1.6 and 2.0 by placing nozzle inserts over the permanent sonic nozzle. At all Mach numbers, the stagnation pressure can be varied from 300 to 3.700 psfa. The test section is 4 ft square and 12.5 ft long with perforated, variable-porosity (0.5- to 10-percent open) walls. It is completely enclosed in a plenum chamber from which the air can be evacuated, allowing part of the tunnel airflow to be removed through the perforated walls of the test section. A more complete description of the tunnel may be found in the Test Facilities Handbook.[1]

B. TUNNEL A

Tunnel A is a continuous, closed-circuit, variable-density wind tunnel with an automatically driven flexible-plate-type nozzle and a 40- by 40-in. test section. The tunnel can be operated at Mach numbers from 1.5 to 6 at maximum stagnation pressures from 29 to 200 psia, respectively, and stagnation temperatures up to 750°R ($M_\infty = 6$). Minimum operating pressures range from about one-tenth to one-twentieth of the maximum at each Mach number. The tunnel is equipped with a model injection system which

1. Test Facilities Handbook (Tenth Edition), Arnold Engineering Development Center, Arnold Air Force Station, Tennessee, May 1974.

allows removal of the model from the test section while the tunnel remains in operation.

Table 1 contains a summary of the nominal test conditions for both wind tunnels.

TABLE 1. NOMINAL TEST CONDITIONS

A. 4T

M_∞	P_t	q_∞	$Re \times 10^{-6}$
0.40	1,600	161	1.9
0.60	1,200	237	2.0
0.80	1,200	353	2.3
0.90	1,200	402	2.4
0.95	1,200	424	2.5
1.00	1,200	444	2.5
1.05	1,200	461	2.6
1.10	1,200	476	2.6
1.25	1,200	507	2.6
1.30	1,200	512	2.6

B. TUNNEL A

M_∞	P_o, psia	T_o, °R	q_∞, psia	P_∞, psia	Re_∞/ft $\times 10^{-6}$
1.76	8.6	560	3.45	1.591	2.31
2.00	9.7	560	3.47	1.240	2.37
2.26	11.4	560	3.47	0.971	2.46
2.50	13.6	570	3.48	0.796	2.54
3.01	20.2	580	3.44	0.542	2.81
4.51	70.9	600	3.44	0.242	4.33

At some test conditions, particularly at sub-atmospheric stagnation pressures, the air humidity level affects the test section Mach number. The Tunnel A sidewall Mach number probe is used periodically when testing at these conditions to monitor deviations from the standard calibration Mach numbers. When a deviation is measured, the free-stream conditions are corrected and the actual Mach number is printed on the data tabulations.

3. MODEL

The Free Flight Demonstration Rocket model is a sting-mounted body of revolution with a diameter of 2.5 in. It has a three-caliber tangent ogive nose and an 11.58-caliber

afterbody that has a stepdown or cutout for wraparound fin attachment. The fins are rectangular and wraparound with a chord of 0.6012 calibers and an exposed semi span of 0.6308 calibers. The model has two sets of fins, one for the fully open case and another for the fully closed case. A removable launch ring or bore rider is also included. It can be mounted in three different positions; however, it was tested only in the aft position. Model details are shown in Figure 1. A complete model description is contained in TDK 14200 series drawings. Table 2 contains a summary of the configurations tested.

TABLE 2. FREE FLIGHT DEMONSTRATION ROCKET CONFIGURATIONS

BRO	Body Alone, Ring Off[1]
BRA	Body Alone, Ring in Aft Position[1]
BFFRA	Body Fins Folded, Ring in Aft Position
BFORA	Body Fins Open, Ring in Aft Position
B3FORA	Body 3 Fins Open, Ring in Aft Position[2]
B2FORA	Body 2 Fins Open, Ring in Aft Position[3]
BFORO	Body Fins Open, Ring Off

NOTES

1. For the body alone cases, all of the fin hardware including the pins and the springs was removed.

2.  Left fin replaced with folded fin at $\phi = 0$ when looking forward from aft. The spring was not installed on the folded fin.

3.  Top and left fins replaced with folded fins at $\phi = 0$ when looking forward from aft. The spring was not installed on the folded fin.

4. BALANCE

All force and moment data were obtained on a six-component strain gage balance fully described in the TDK 14100 series drawings. Load limits for the balance are 80 lb normal force, 50 lb axial force, 40 lb side force, 160 in.-lb pitching moment, 120 in.-lb yawing moment, and 30 in.-lb rolling moment.

5. DATA REDUCTION

The reference length and area for the Free Flight Demonstration Rocket model are the diameter and the cross-sectional area, respectively. The numerical values are 2.5

in. and 4.91 in. square. The pitching moment and the yawing moment are referenced to the model nose. In addition to the basic force and moment data, the base pressure, P_b/P_∞, was also measured. The uncertainty of the aerodynamic coefficients is shown in Table 3.

In addition to the numerical data obtained in Tunnel A, Schlieren photographs for each run number were made at angles of attack of 1 deg and 3 deg for all configurations.

TABLE 3. UNCERTAINTY OF AERODYNAMIC COEFFICIENTS

A. 4T

M_∞	ΔM_∞	Δq_∞, psf	ΔC_N	ΔC_Y	ΔC_A	ΔC_m	ΔC_n	ΔC_ℓ
0.40	±0.007	±5.45	±0.05	±0.02	±0.04	±0.51	±0.18	±0.006
0.60	±0.006	±3.96	±0.04	±0.01	±0.02	±0.34	±0.12	±0.004
0.80	±0.005	±3.27	±0.02	±0.01	±0.02	±0.23	±0.08	±0.002
0.90	±0.004	±2.95	±0.02	±0.01	±0.01	±0.20	±0.07	±0.002
1.00	±0.004	±2.60	±0.02	±0.01	±0.01	±0.19	±0.06	±0.002
1.10	±0.004	±2.28	±0.02	±0.01	±0.01	±0.17	±0.06	±0.002
1.25	±0.004	±1.90	±0.02	±0.01	±0.01	±0.16	±0.06	±0.002

B. TUNNEL A

	Maximum Coefficient Uncertainty (±)						
M_∞	C_N	C_m	C_Y	C_n	C_ℓ	C_{A_t}	C_A
1.76	0.0104	0.1023	0.0091	0.0915	0.0037	0.0095	0.0156
2.00	0.0114	0.1067	0.0092	0.0924	0.0039	0.0101	0.0150
2.50	0.0113	0.1039	0.0090	0.0903	0.0038	0.0097	0.0114
3.01	0.0145	0.1202	0.0093	0.0932	0.0041	0.0106	0.0122

6. RESULTS AND DISCUSSION

An analysis of the data shows no unusual trends. Typical transonic and supersonic data are shown in Figures 2 and 3. As these figures show, the data is linear throughout the angle-of-attack range, and especially at small angles of attack where free rockets fly. The configuration tested provides acceptable stability.

Since the actual rocket will fly with a bore ride or launch ring attached, its effect on the missile must be determined. Figure 4 shows the normal force and center of

pressure for body alone with and without the bore rider. Figure 5 shows these parameters for the body fin configuration. As can be seen, the effects on the stability of the vehicle caused by the addition of the launch ring are negligible. As one might expect, the overall drag of the vehicle is increased. This is shown in Figures 6 and 7 for the body alone and the body fin cases.

Since the Free Flight Demonstration Rocket uses wraparound fins for its stability, the effect of the curvature of the fins must be evaluated. Dahlke[2] points out the following characteristics of wraparound fins:

- There is an induced rolling moment at zero angle of attack. The direction of the rolling moment varies with Mach number. Additionally, step-downs on the afterbody show an additional crossover of the induced rolling moment at supersonic Mach numbers.

- The rolling moment variation with angle of attack is small for angles less than 2 deg. Above 2 deg the rolling moment may deviate significantly from the zero alpha case.

- Cross derivatives (i.e., yawing moment due to pitch, etc.) induced by the wraparound fin do not appear to be significant at Mach numbers below 2.5. It should be noted that the induced rolling moments for the Free Flight Demonstration Rocket are opposite in direction to those in Reference 2 because the fins are curved in opposite directions.

Figure 8 shows the rolling moment at zero angle of attack plotted against Mach number. The data agree with the results from Dahlke.[2] There is an induced rolling moment that is measurable, and it does vary with Mach number. It also has the crossover point in the supersonic range.

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2. C. W. Dahlke, The Aerodynamic Characteristics of Wraparound Fins at Mach Numbers of 0.3 to 3.0, US Army Missile Command, Redstone Arsenal, Alabama, Report No. RD-77-4.

Figures 9 and 10 are plots of rolling moment versus angle of attack. For the Free Flight Demonstration Rocket the rolling moment does not change significantly with angles of attack above 2 deg as shown by Dahlke.

In earlier wraparound fin studies, it was shown that there is some variation in the lateral derivative, C_y, with angle of attack. However, Dahlke[2] could not duplicate the variation in side force. The results in Figures 11 and 12 for the transonic and supersonic Mach numbers show that there is no variation in the side force with angle of attack for the Free Flight Demonstration Rocket. This supports Dahlke's conclusion that the cross derivative produced by wraparound fins may not be significant below a Mach number of 2.5.

Since the purpose of the wind tunnel tests was to verify the predicted coefficients, a discussion of the differences noted is in order. Figure 13 shows the actual and predicted values of the normal force and the center of pressure for the body alone case, while Figure 14 shows these coefficients for the body fin combination. The aerodynamic coefficients were predicted by considering the WAF's to be flat fins and then using the techniques described in three Government reports.[3-5] The data show that the actual normal force was in good agreement with that predicted. However, the center of pressure did not agree well, especially at subsonic Mach numbers and for the body alone case. The natural question is why the difference.

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3. A. F. Gafarian and W. L. Phillips, The Supersonic Lift and Centers of Pressure of Rectangular and Clipped Delta Fins in Combination With Long Cylindrical Bodies, US Naval Ordnance Test Station, China Lake, California, Report No. TM-966, 1963.

4. John B. McDevitt, A Correlation by Means of Transonic Similarity Rules of Experimentally Determined Characteristics of a Series of Symmetrical and Cambered Wings of Rectangular Plan Form, National Advisory Committee for Aeronautics, Washington, D. C., NACA Report 1253, 1955.

5. William C. Pitts, Jack N. Nielson, and George E. Kattari, Lift and Center of Pressure of Wing-Body-Tail Combinations at Subsonic, Transonic, and Sup rsonic Speeds, National Advisory Committee for Aeronautics, Washington, D. C., NACA Report 1307, 1959.

Since the actual data showed less stability than the predicted data and since the aft end of the rocket was cut out for fin attachment, it was concluded that the cutout might have much the same destabilizing effects as a boattail. The effects of a boattail were calculated assuming a boattail of the same length and diameter ratio as the body cutout using the procedure given in a US Army Missile Command report.[6] The results are shown in Figures 15 and 16. It is evident that a more accurate prediction of the aerodynamic coefficients can be made by considering the aft of the rocket to have a boattail. In Figure 16 the fins' folded case was included to show that without the stepdown for fin attachment, the predictions were good.

As already noted, one boattail effect is destabilizing. However, another effect is a decrease in total configuration drag as a result of decreased base pressure drag. Figure 17 shows that the drag for configuration with the cutout for fin attachment is lower than the configuration without the cutout.

Data was taken to determine the effect of an underexpanded jet plume on the stability of the Free Flight Demonstration Rocket. These data will be published in a forthcoming data report.

Data were taken as a function of roll angle at a Mach number of 0.6 with one fin and two fins folded to simulate delayed fin opening. These data are presented in Figures 18 through 47. The angles of attack are -1, 1, and 3 deg.

7. CONCLUSIONS

1. The configuration selected for the Free Flight Demonstration Rocket provides acceptable aerodynamic stability for its ballistic, unpowered flight phase.

2. The data contained no unusual trends and was linear throughout the angle-of-attack range of interest.

3. The launch ring has little effect on stability. However, total drag is slightly increased.

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6. W. D. Washington, Boattail Effects on Static Stability at Small Angles of Attack, US Army Missile Command, Redstone Arsenal, Alabama, Report No. RD-TM-68-5.

4. The afterbody stepdown for wraparound fin attachment decreases the stability of the configuration. It also reduces drag, helping to offset the increase due to the launch ring.

5. The effects of the wraparound fins agree with previous studies.

6. The prediction of static aerodynamic coefficients for bodies with stepdowns for wraparound fin attachment can be improved by considering the stepdown to act as a boattail.

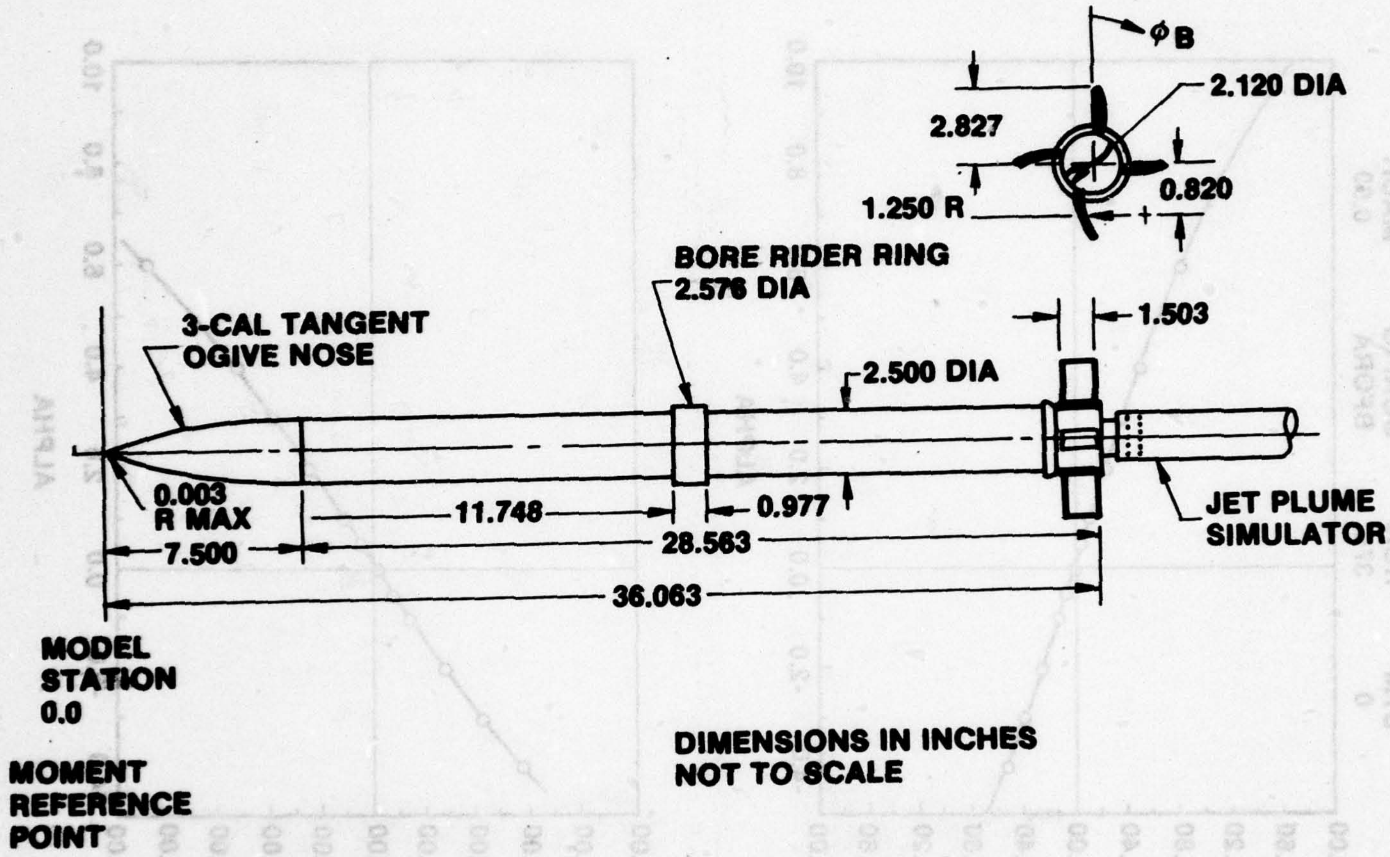


Figure 1. Free Flight Demonstration Rocket model.

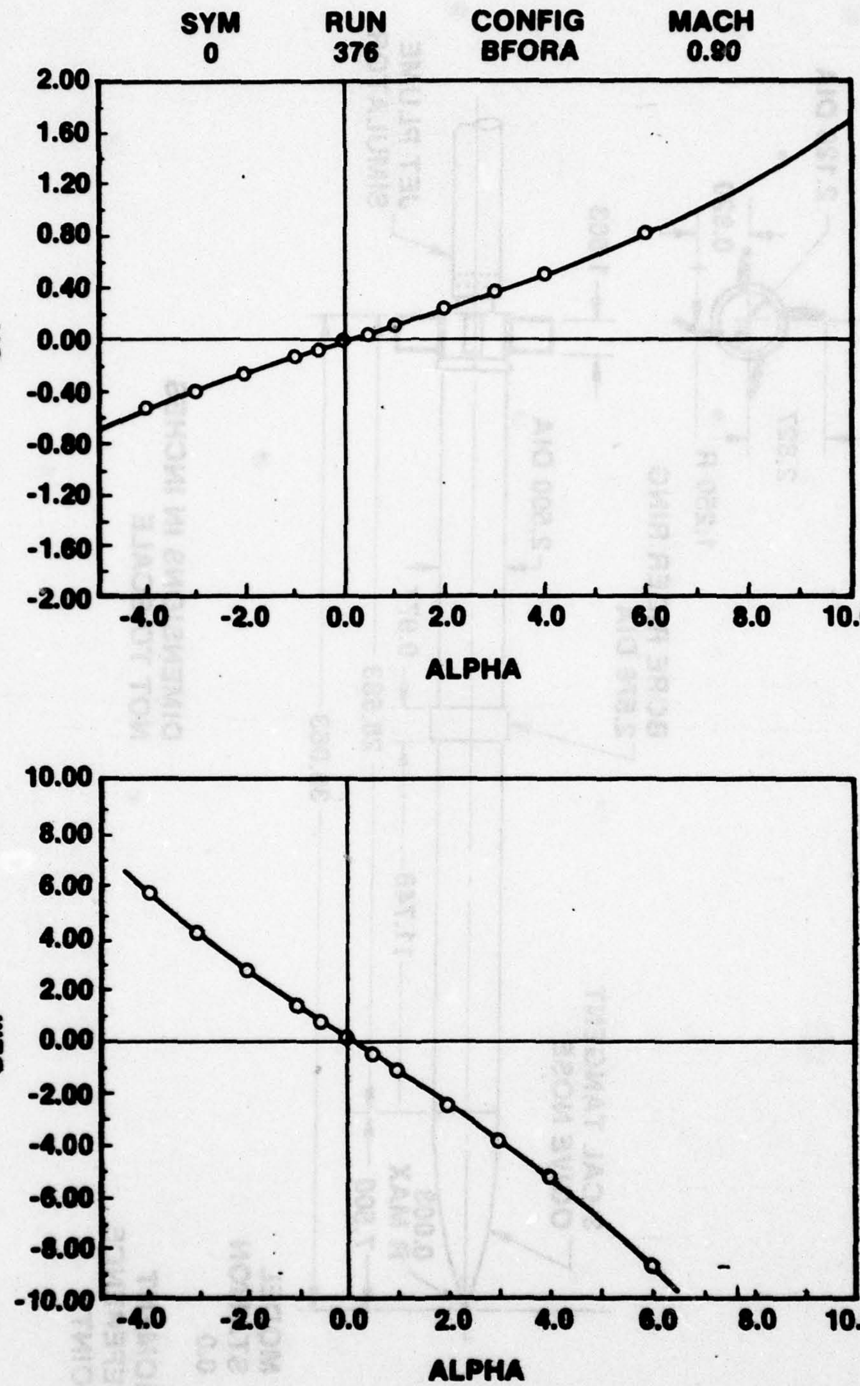


Figure 2. Typical transonic data.

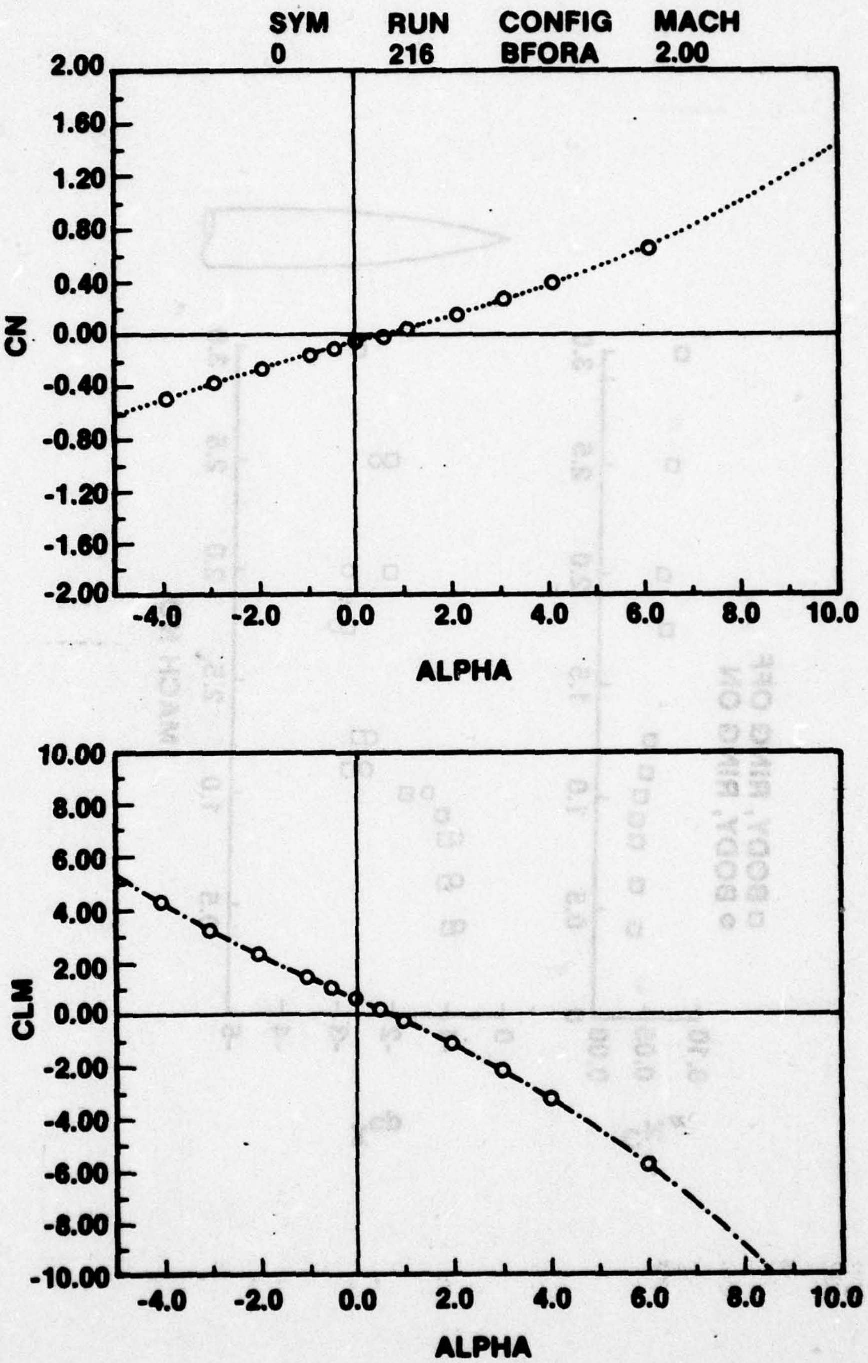


Figure 3. Typical supersonic data.

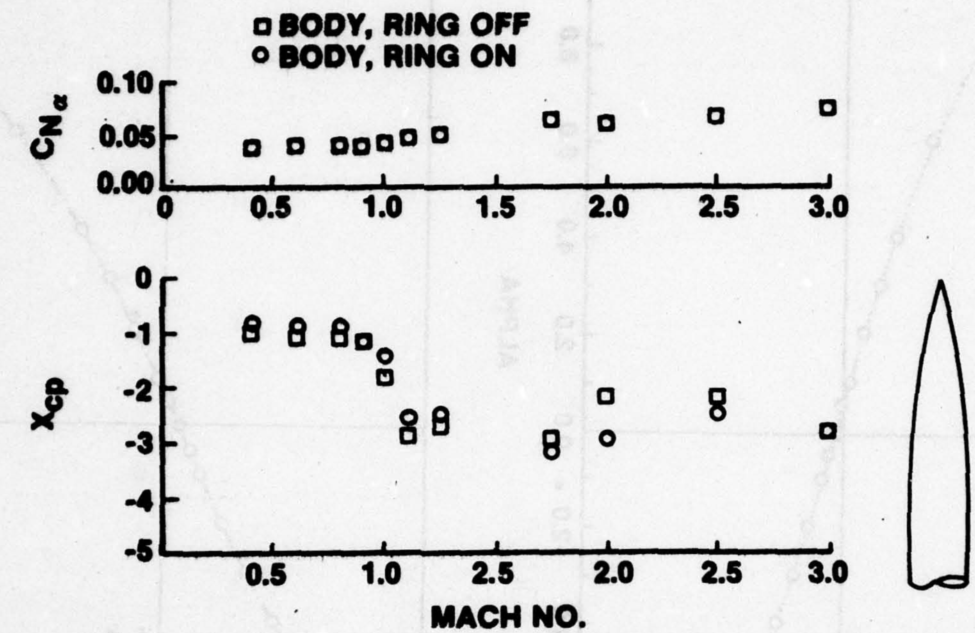


Figure 4. Ring effects on stability.

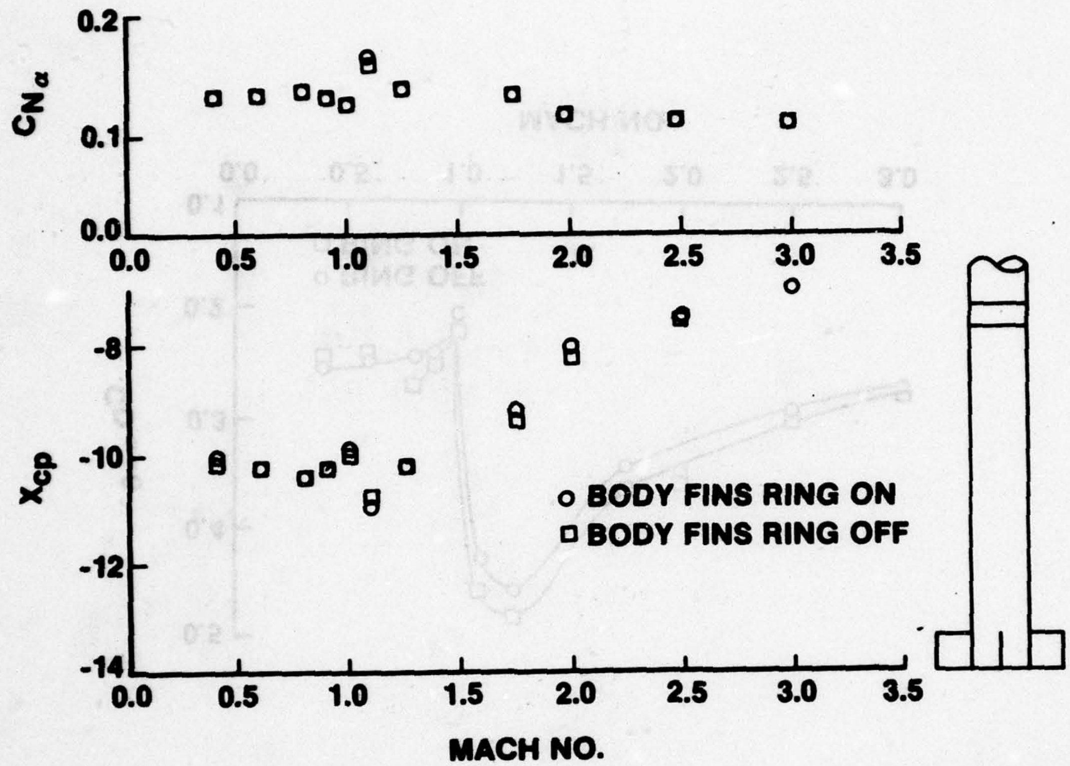


Figure 5. Ring effects on stability.

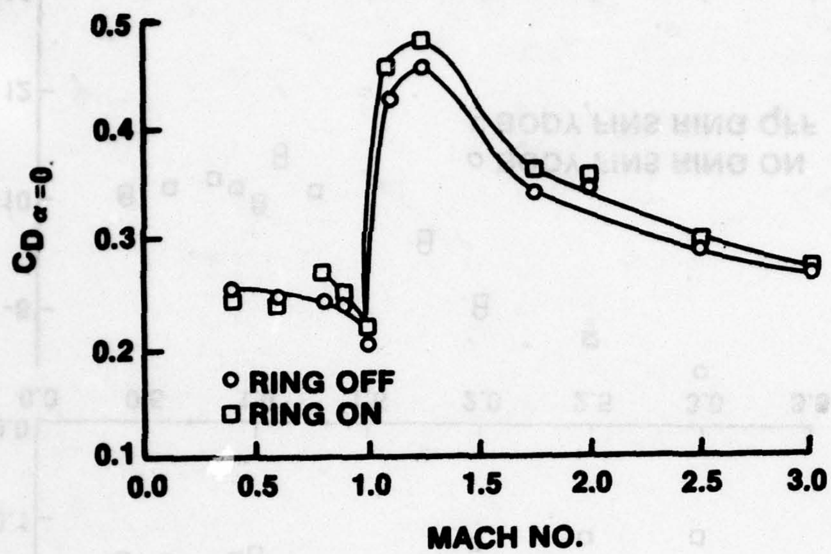


Figure 6. Ring effects on drag - body alone.

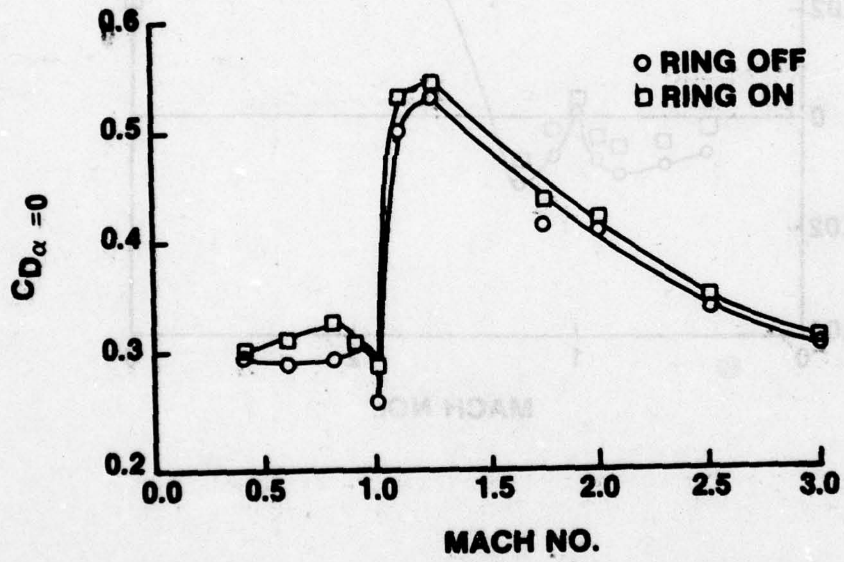


Figure 7. Ring effects on drag - body fin.

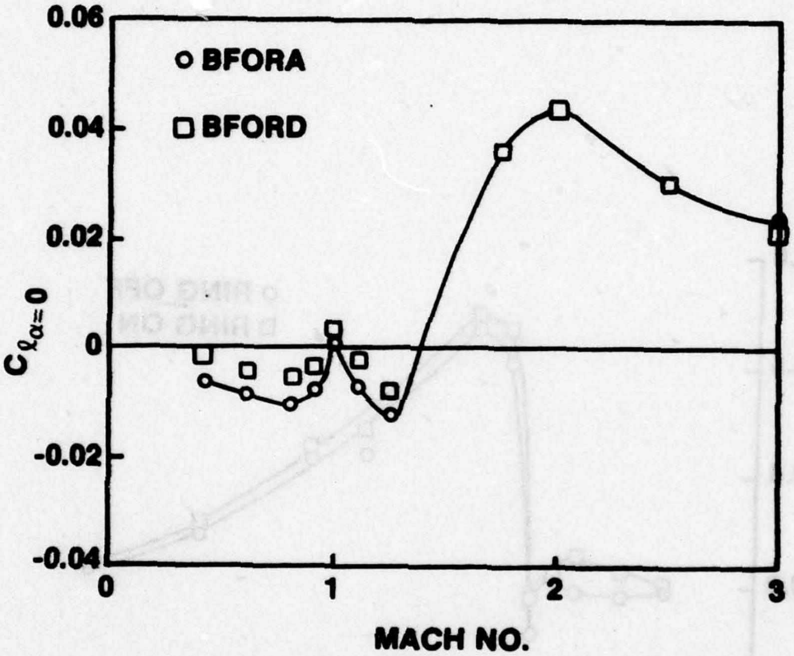


Figure 8. WAF effects rolling moment.

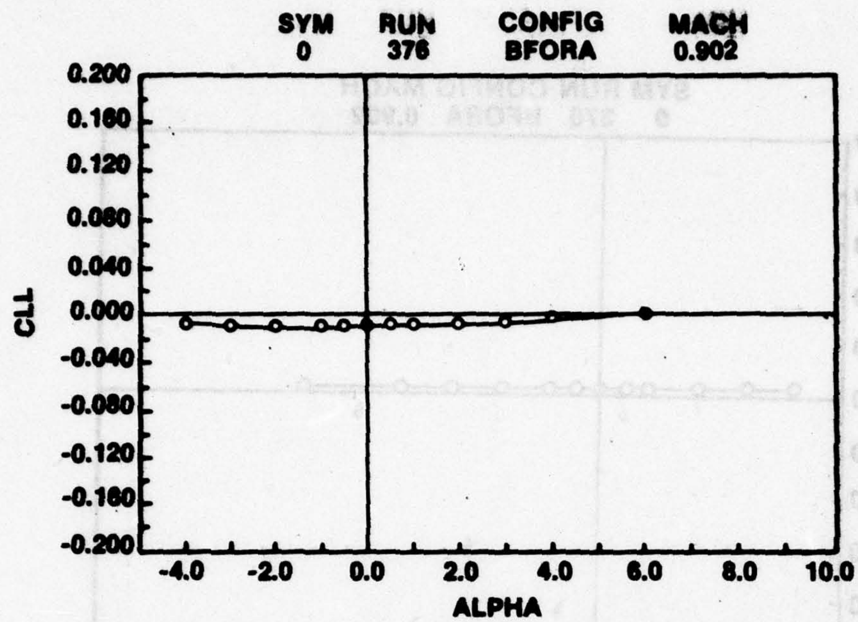


Figure 9. WAF effects rolling moment versus alpha.

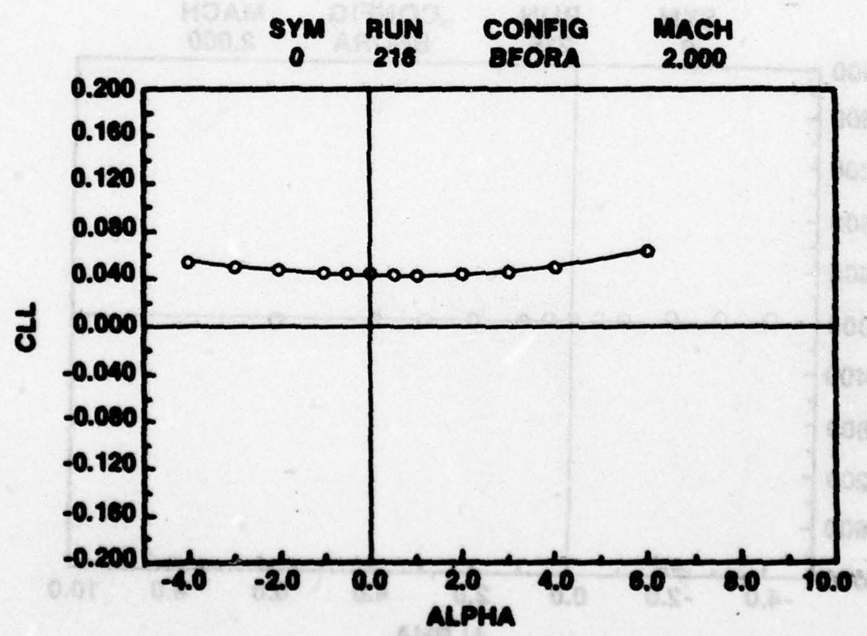


Figure 10. WAF effects rolling moment versus alpha.

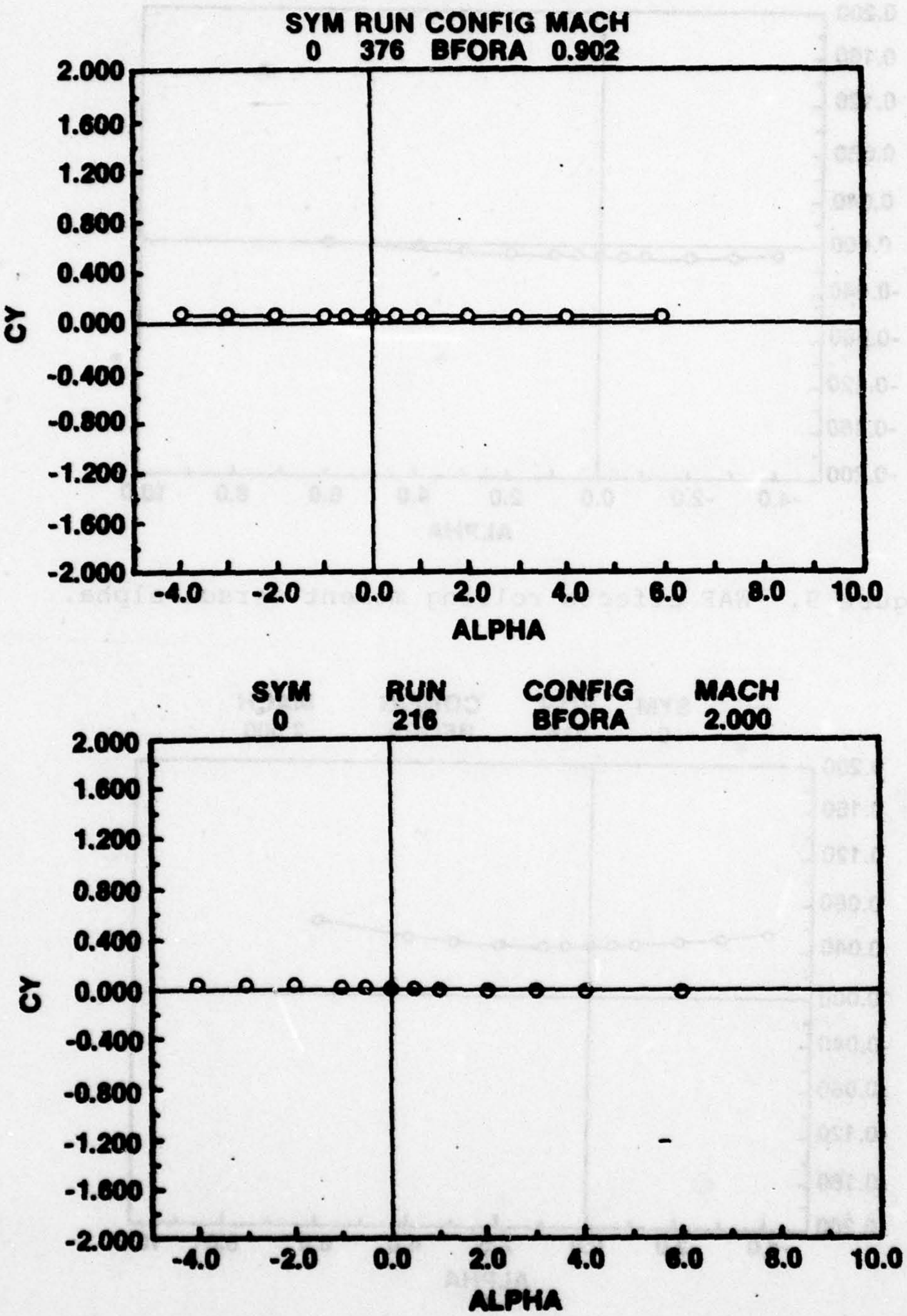


Figure 11. WAF effects side force versus alpha.

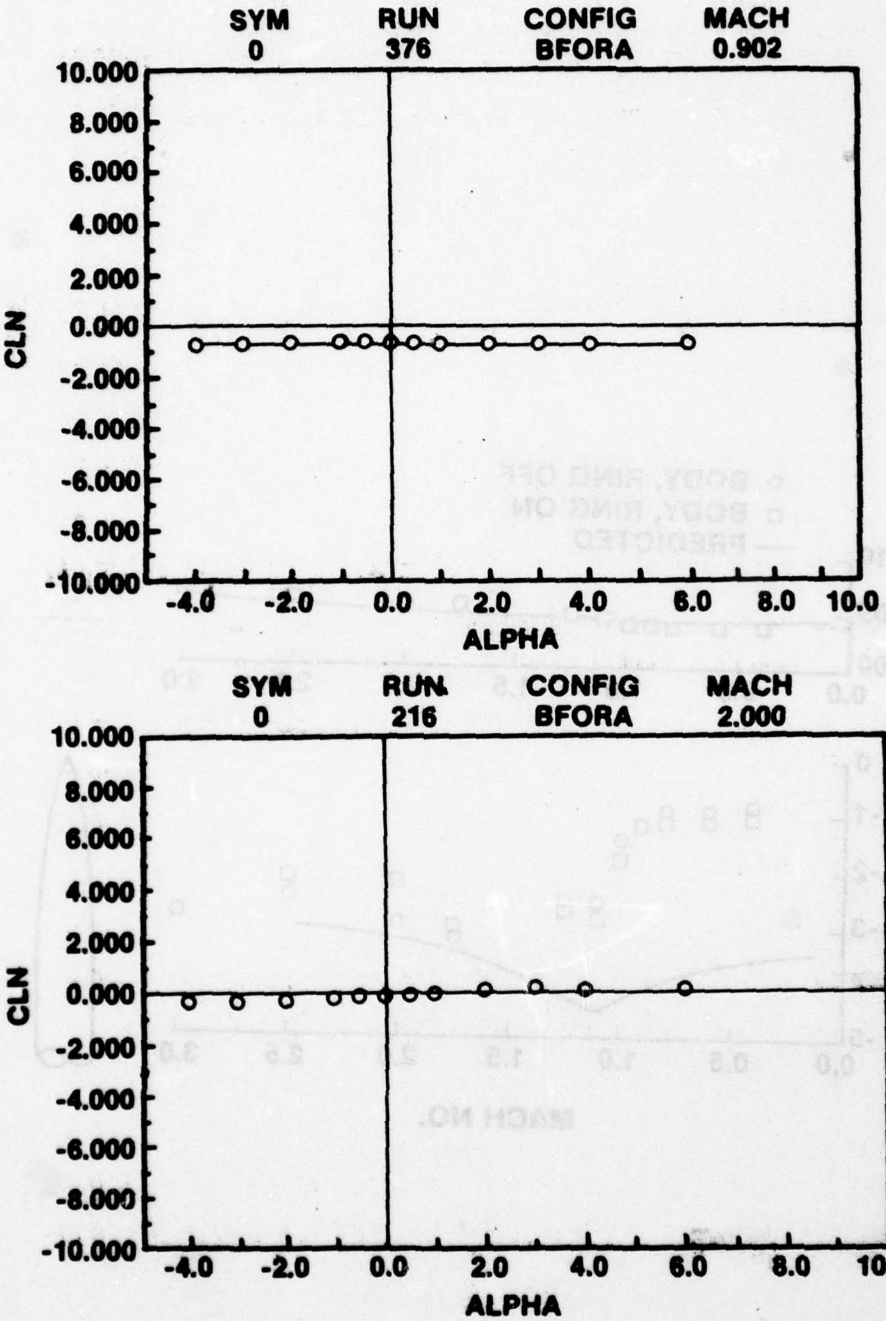


Figure 12. WAF effects yawing moment versus alpha.

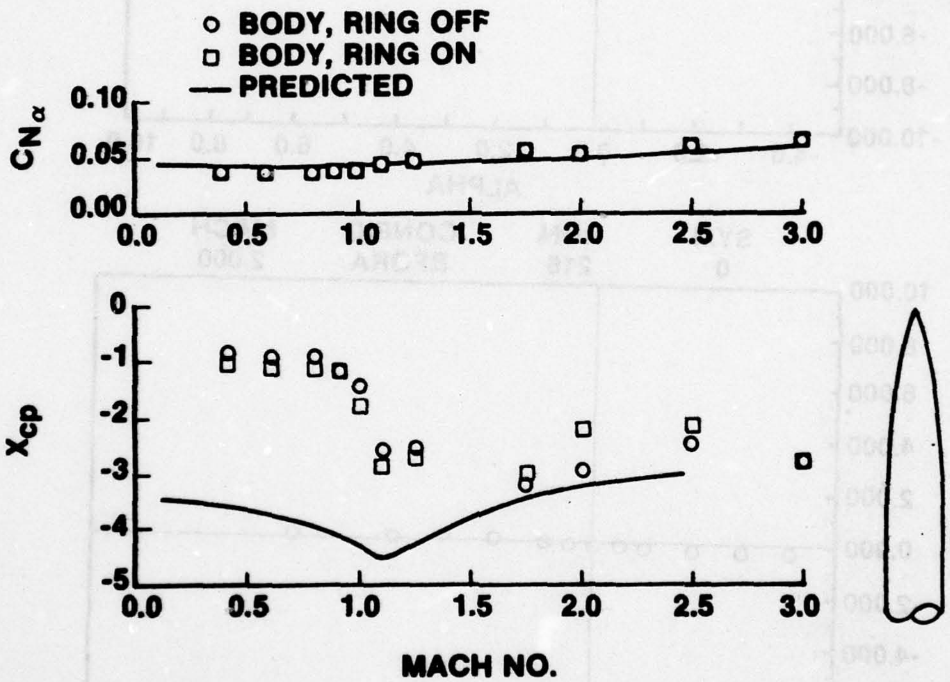


Figure 13. Actual versus predicted.

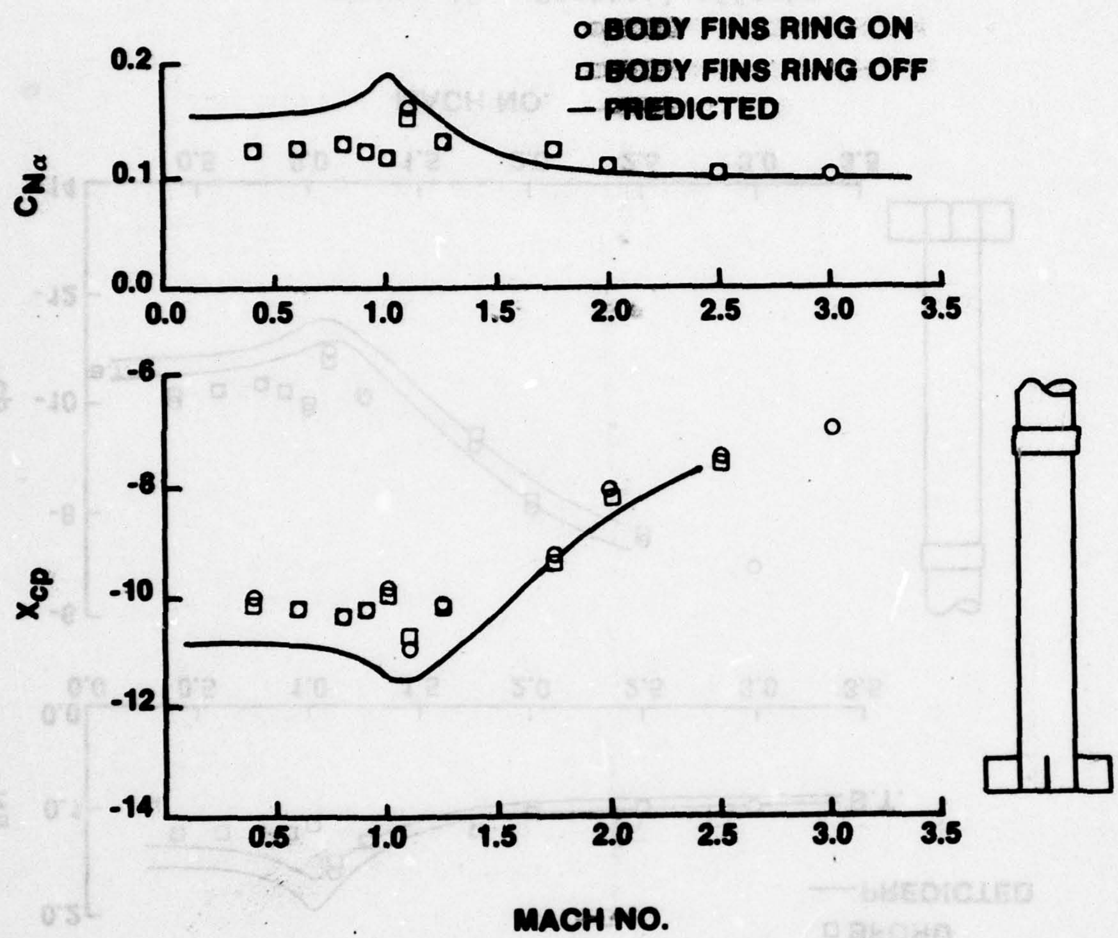


Figure 14. Actual versus predicted.

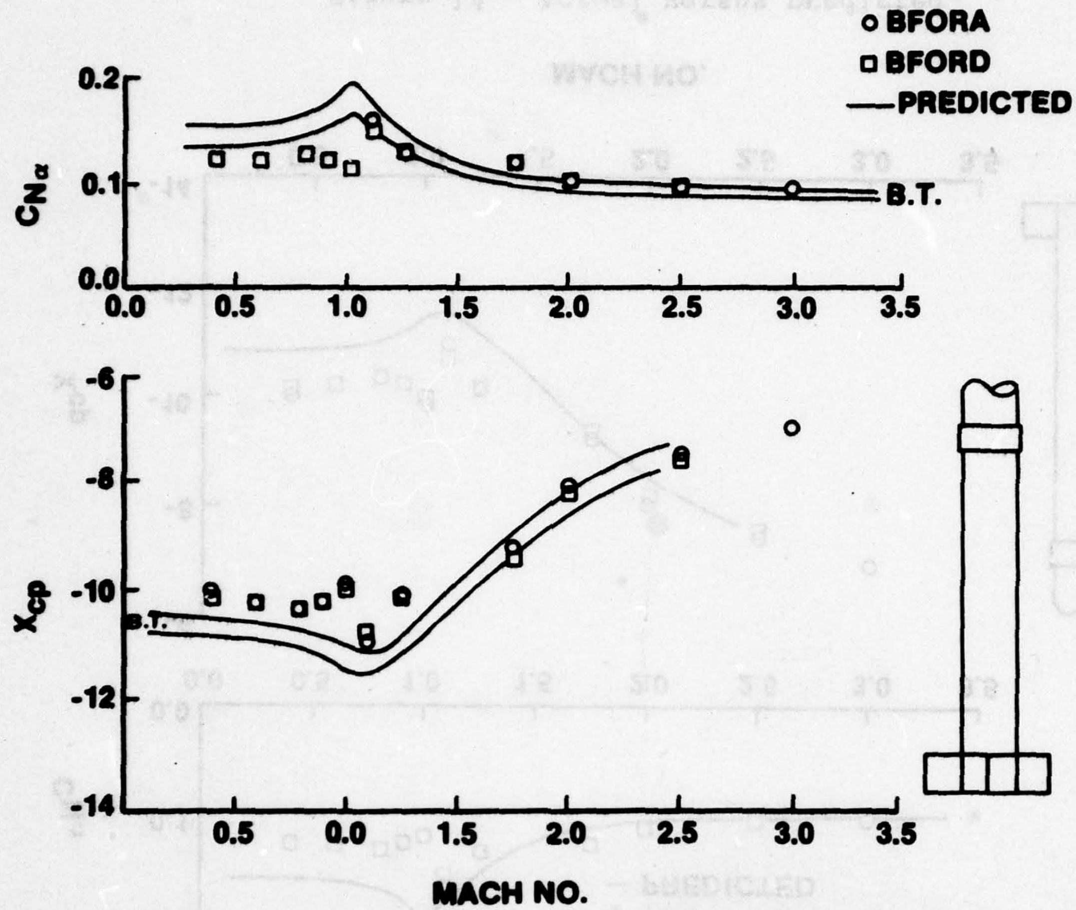


Figure 15. Boattail effects.

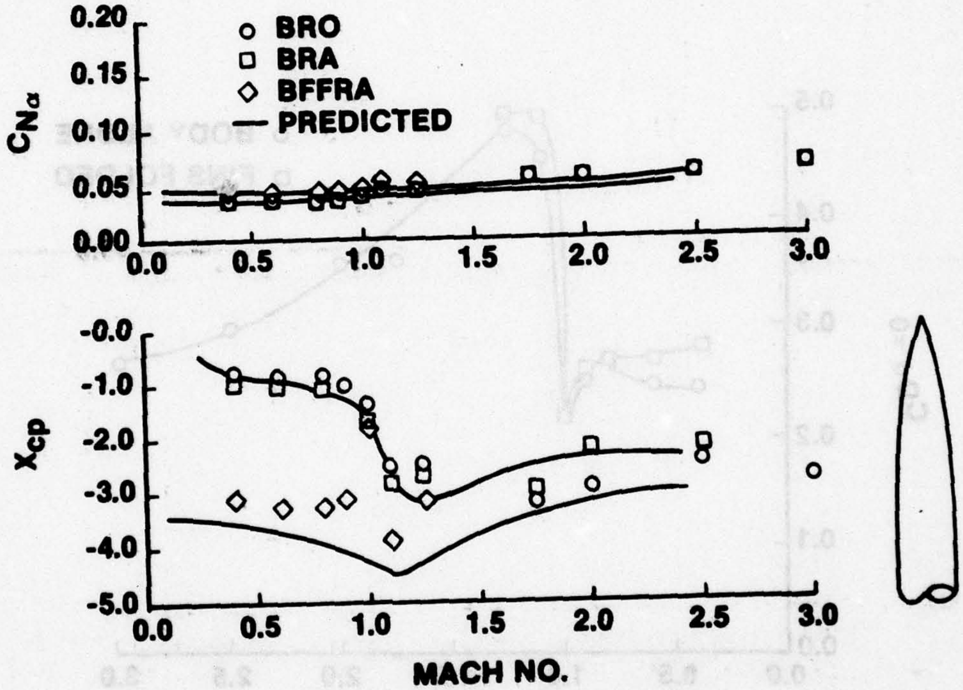


Figure 16. Boattail effects.

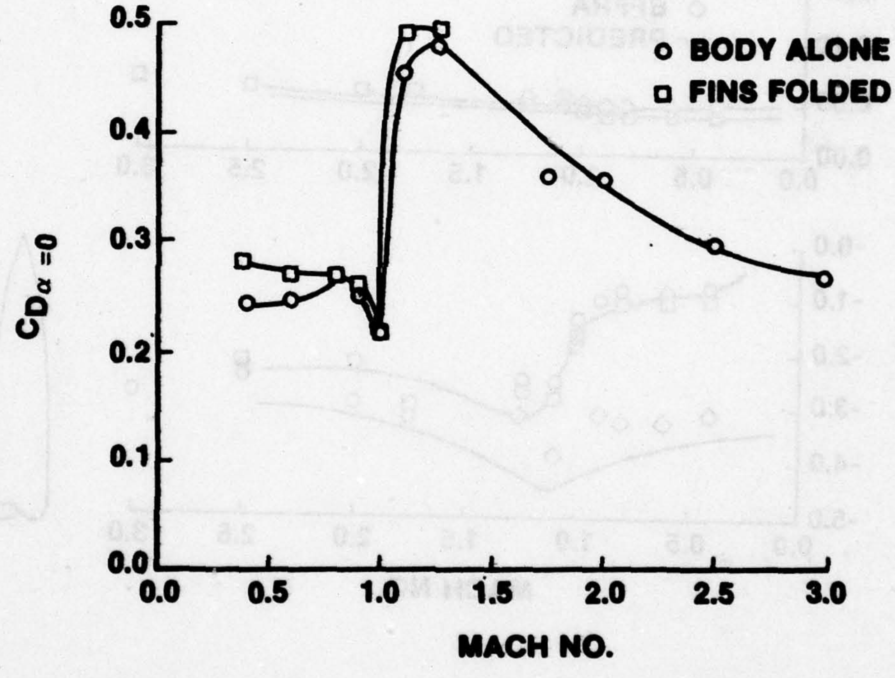


Figure 17. Boattail effects on drag.

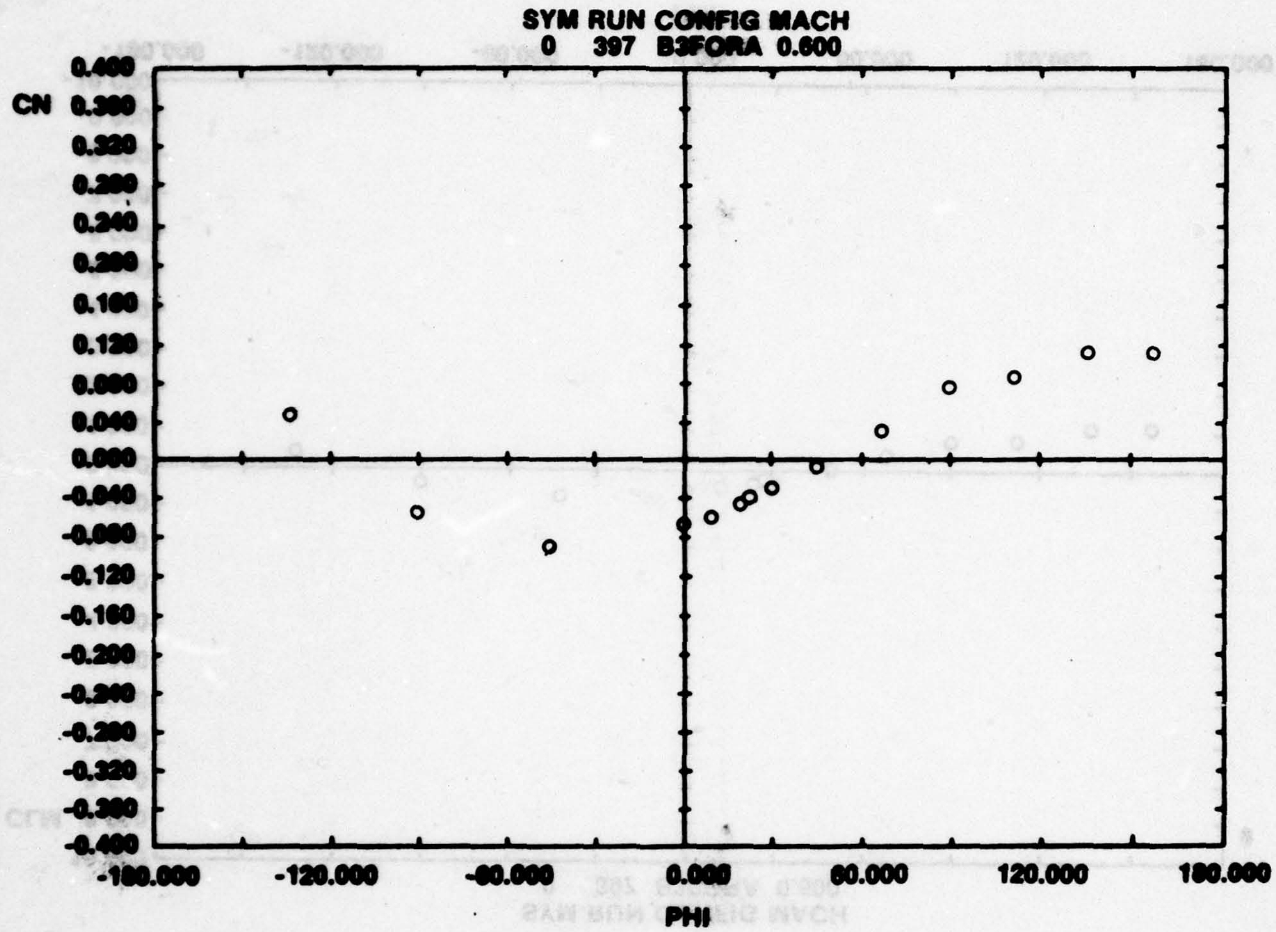
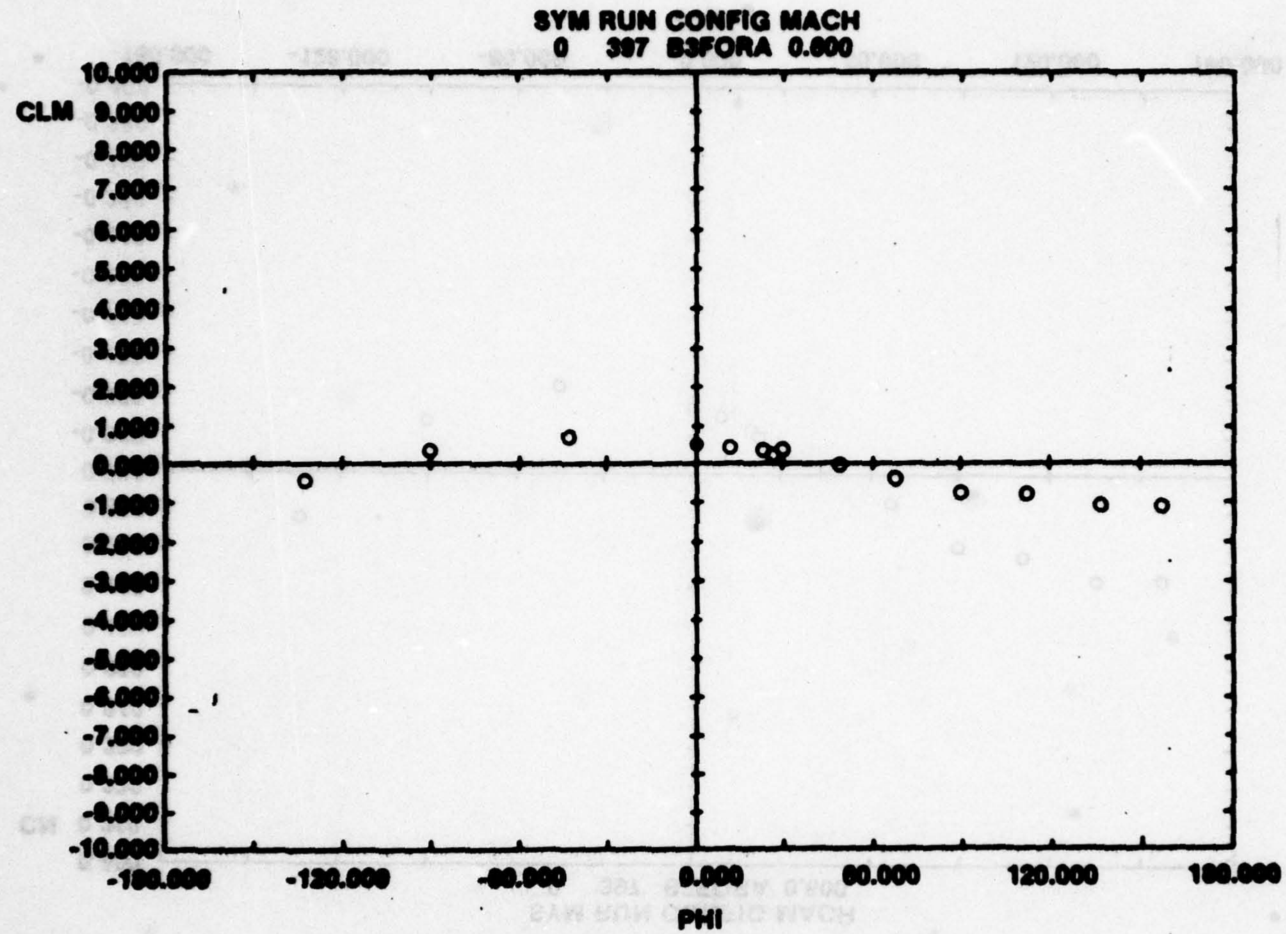


Figure 18. Alpha = -1.



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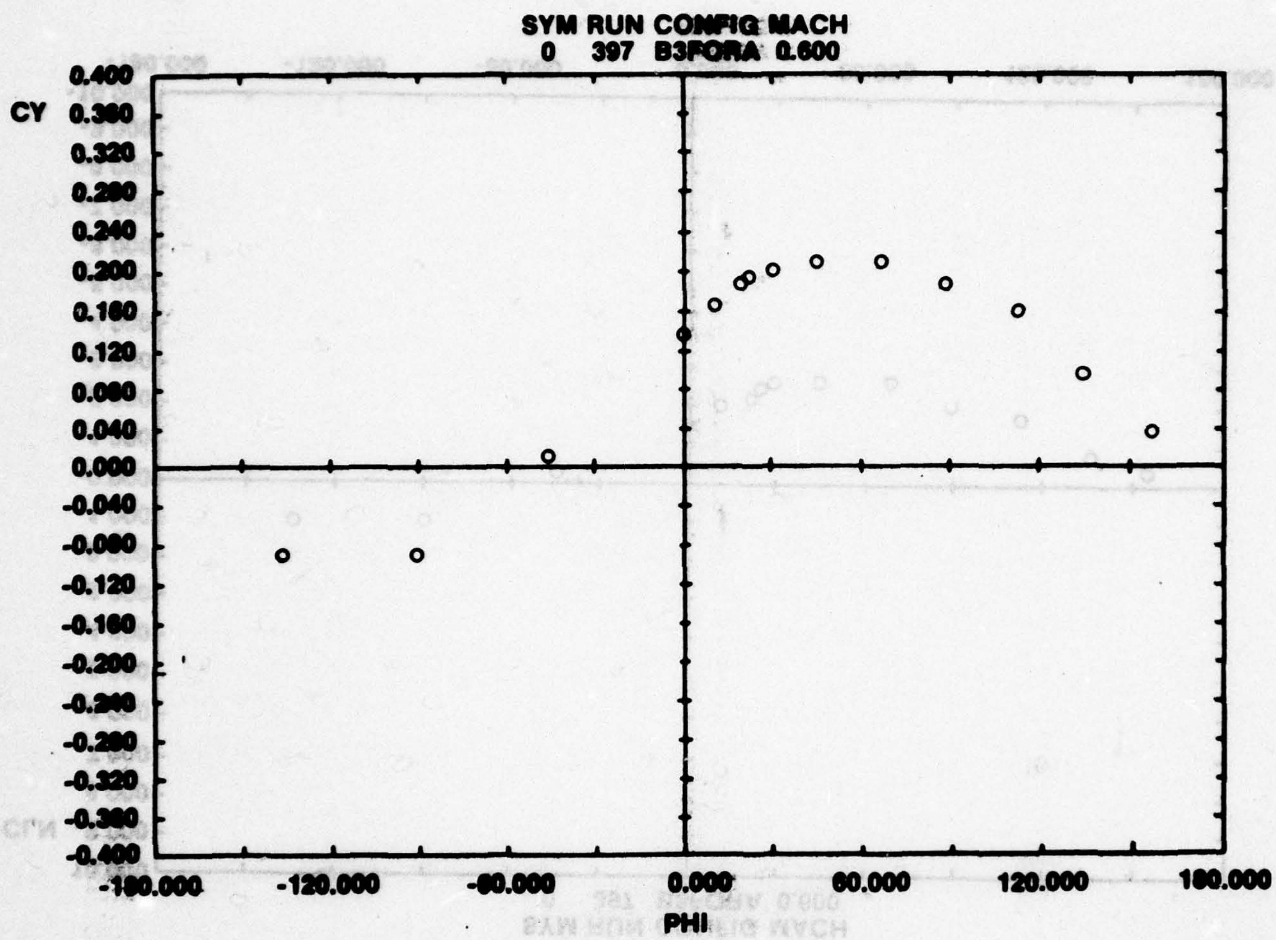
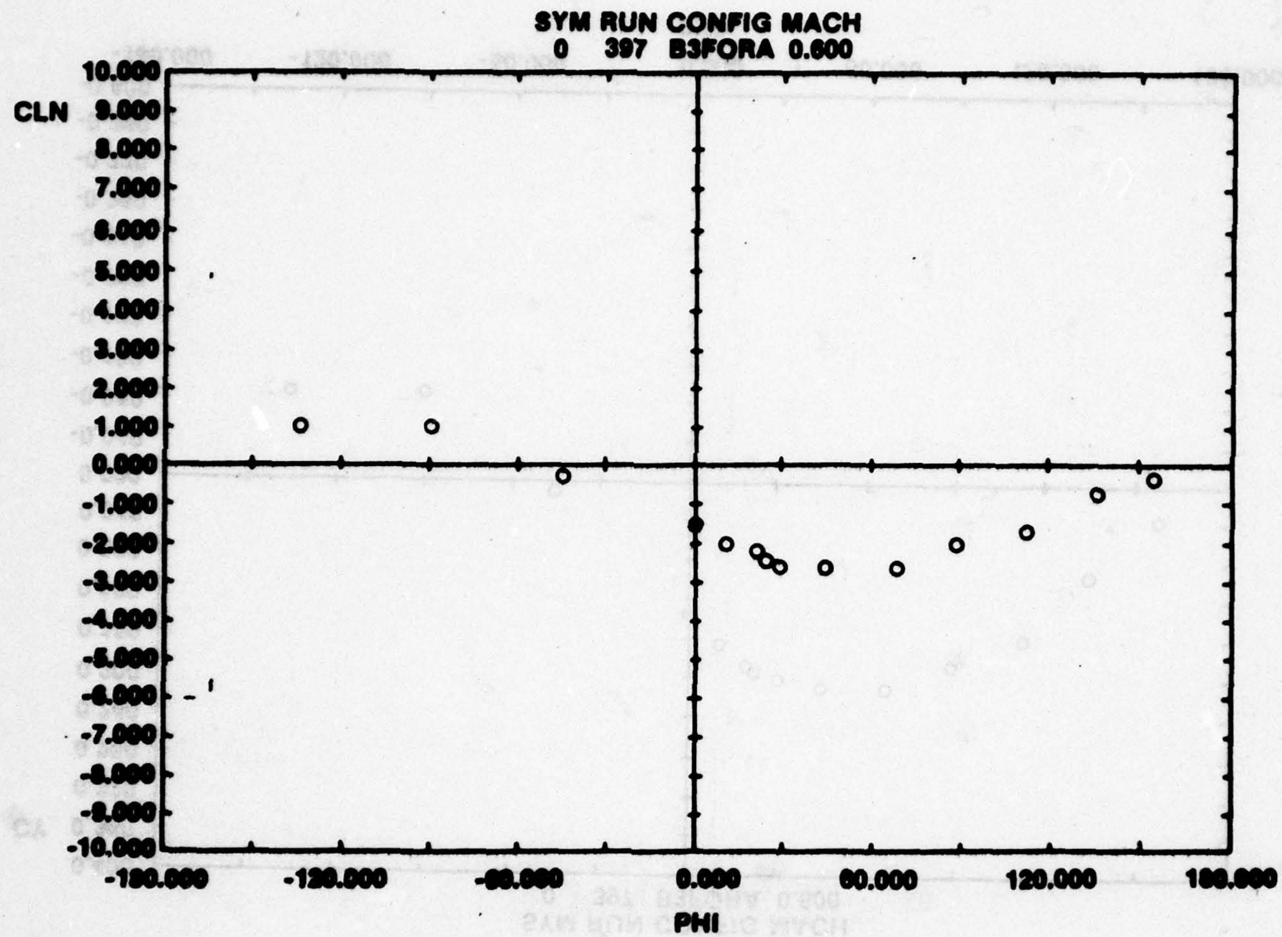


Figure 20. Alpha = -1



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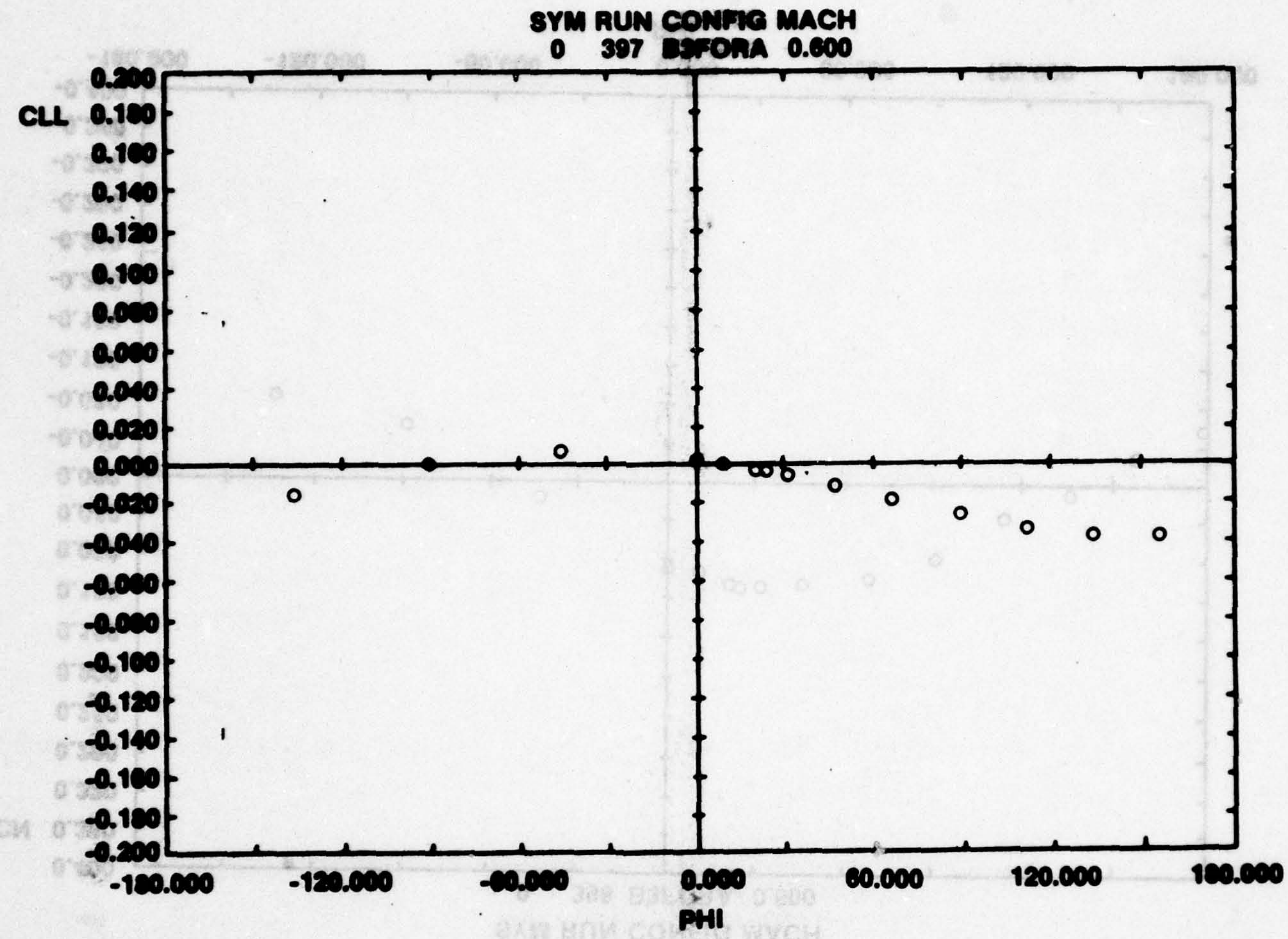

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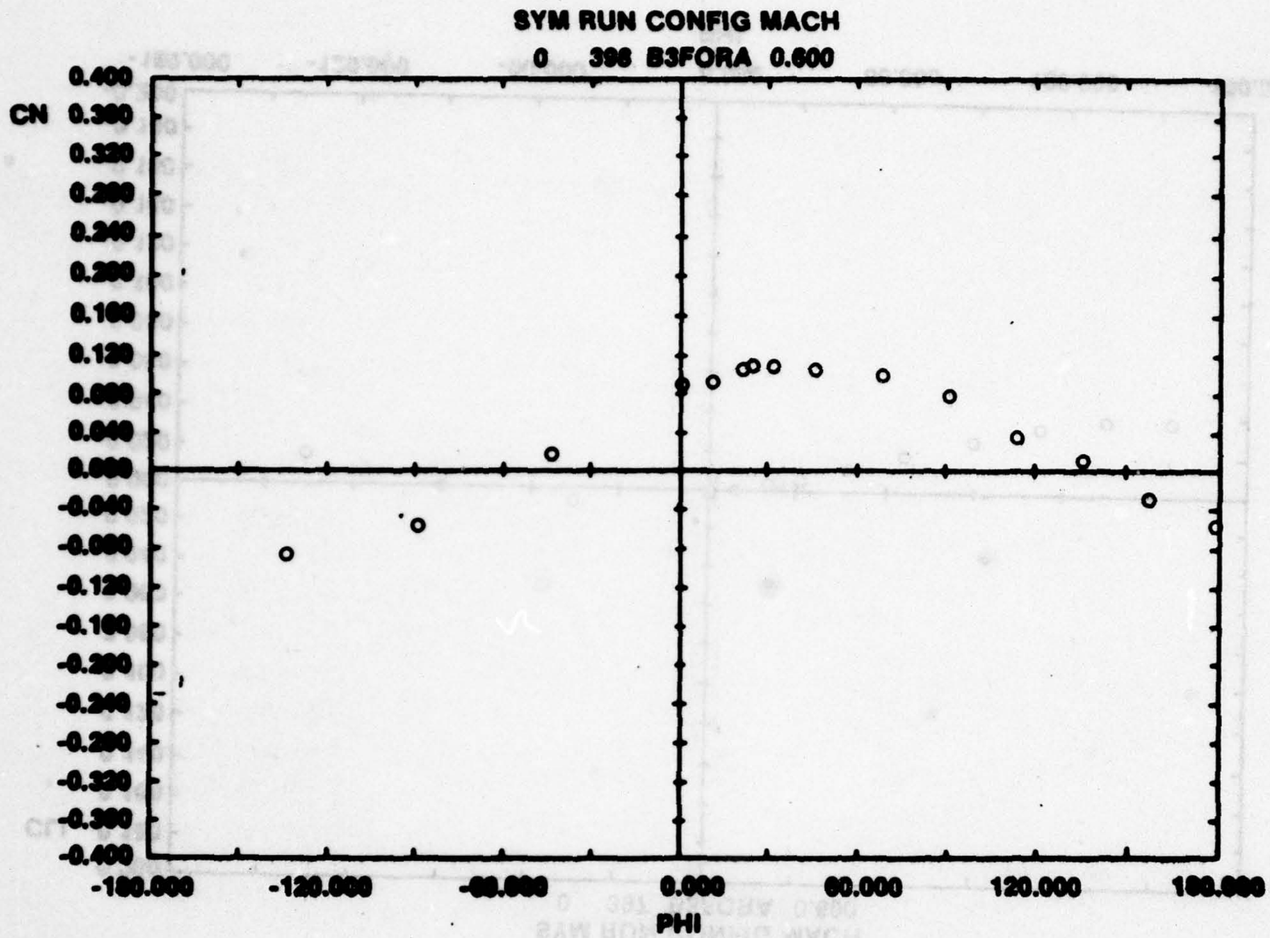
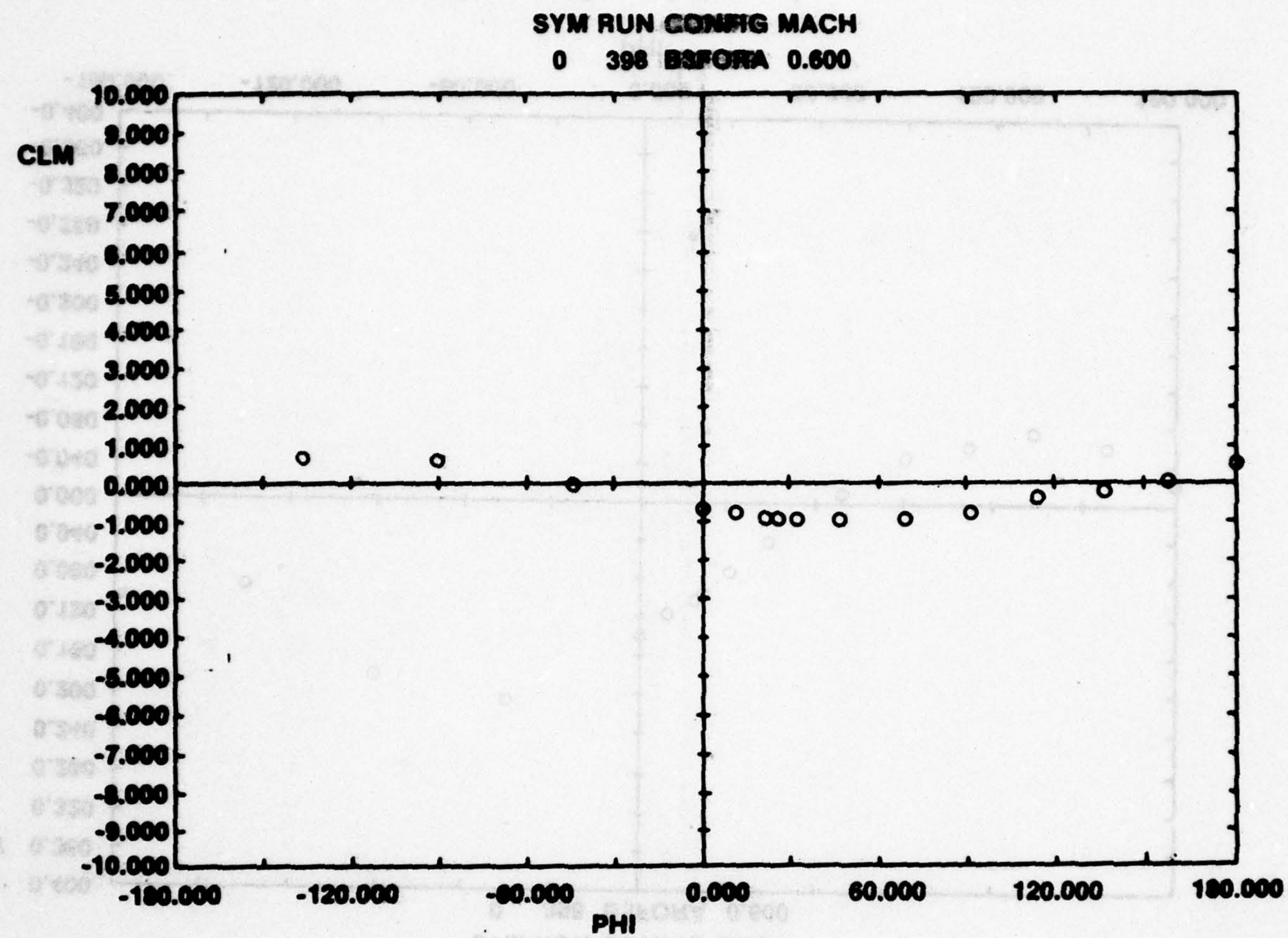


Figure 23. Alpha = 1.



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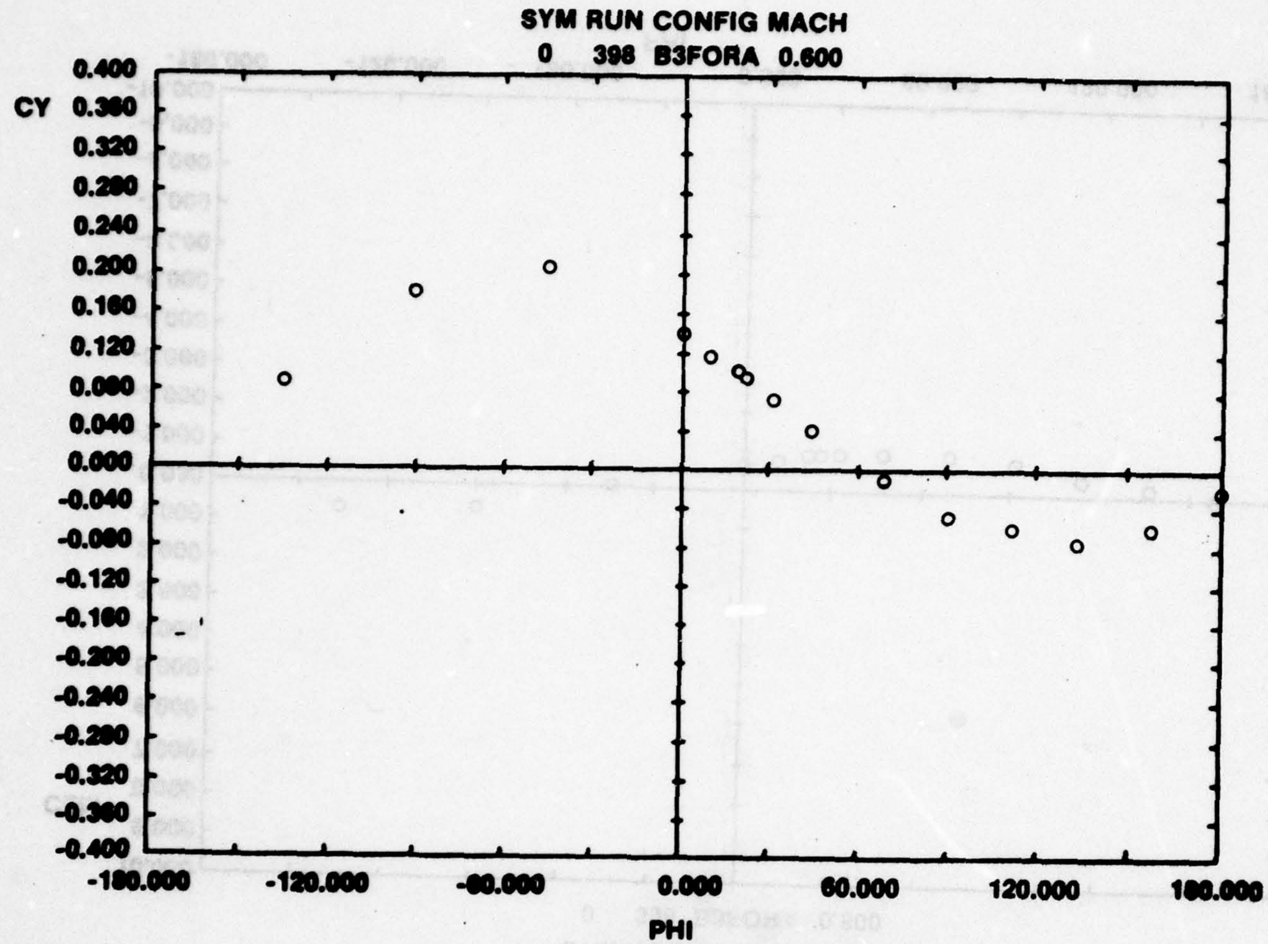

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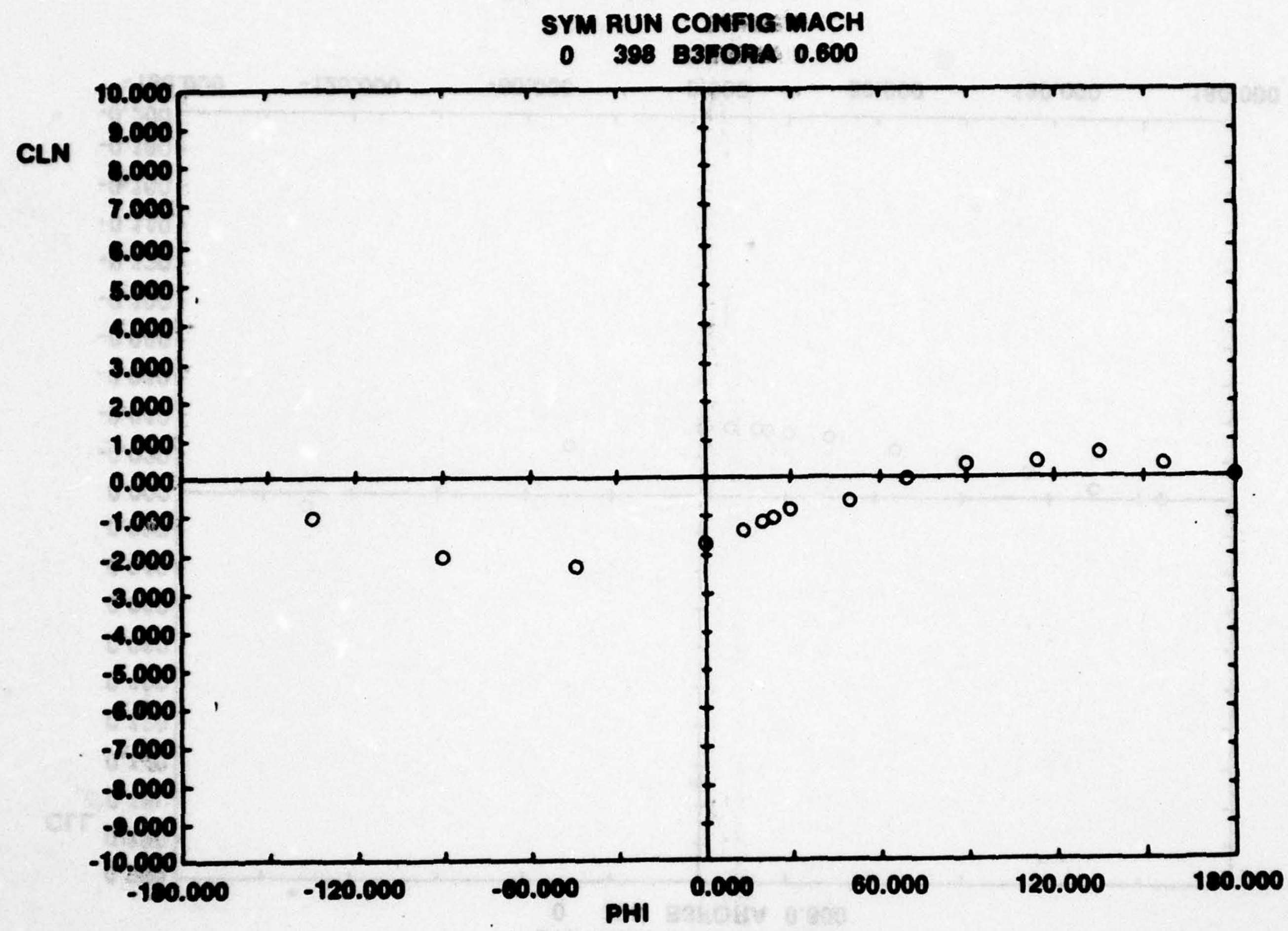

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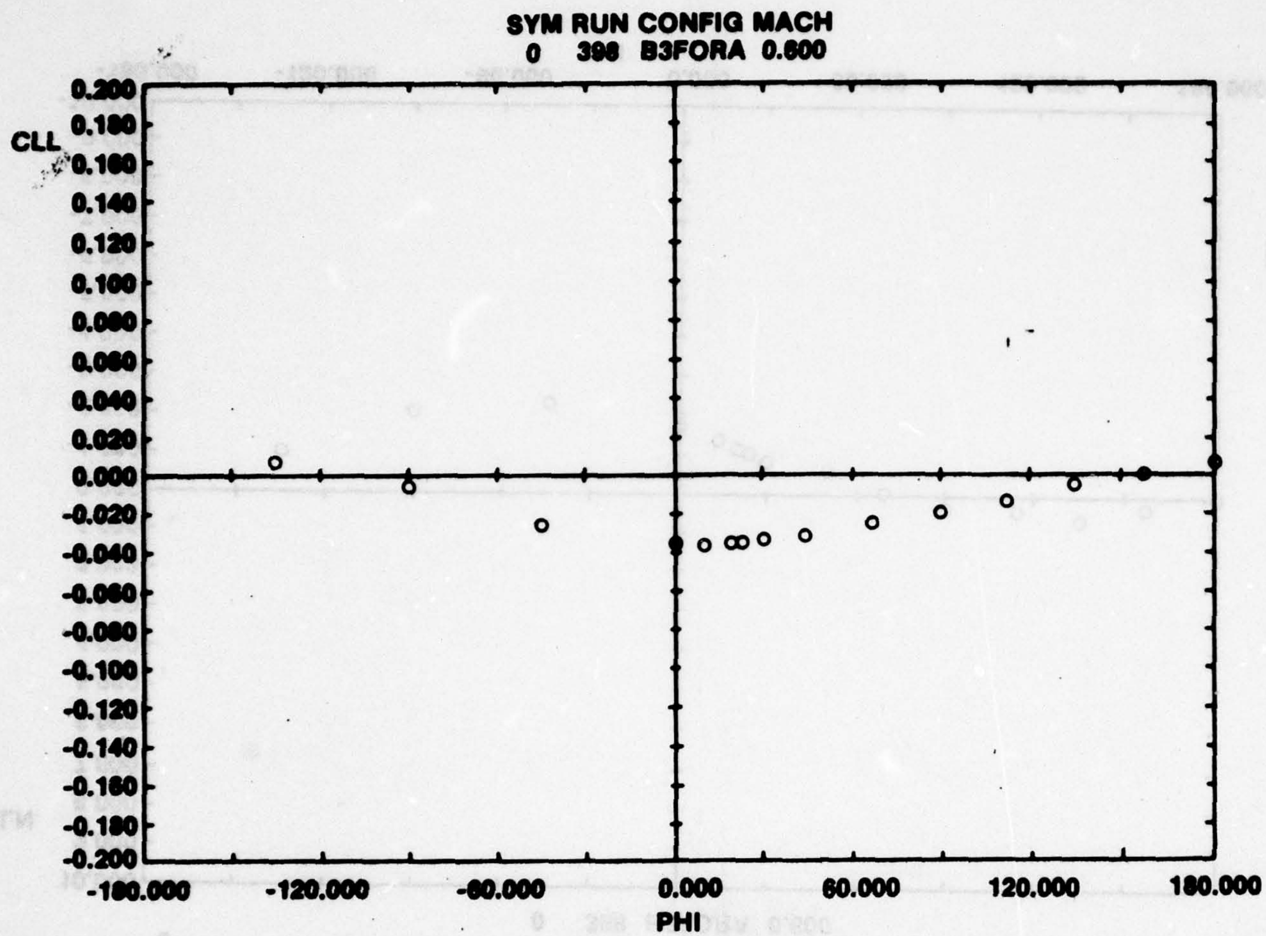
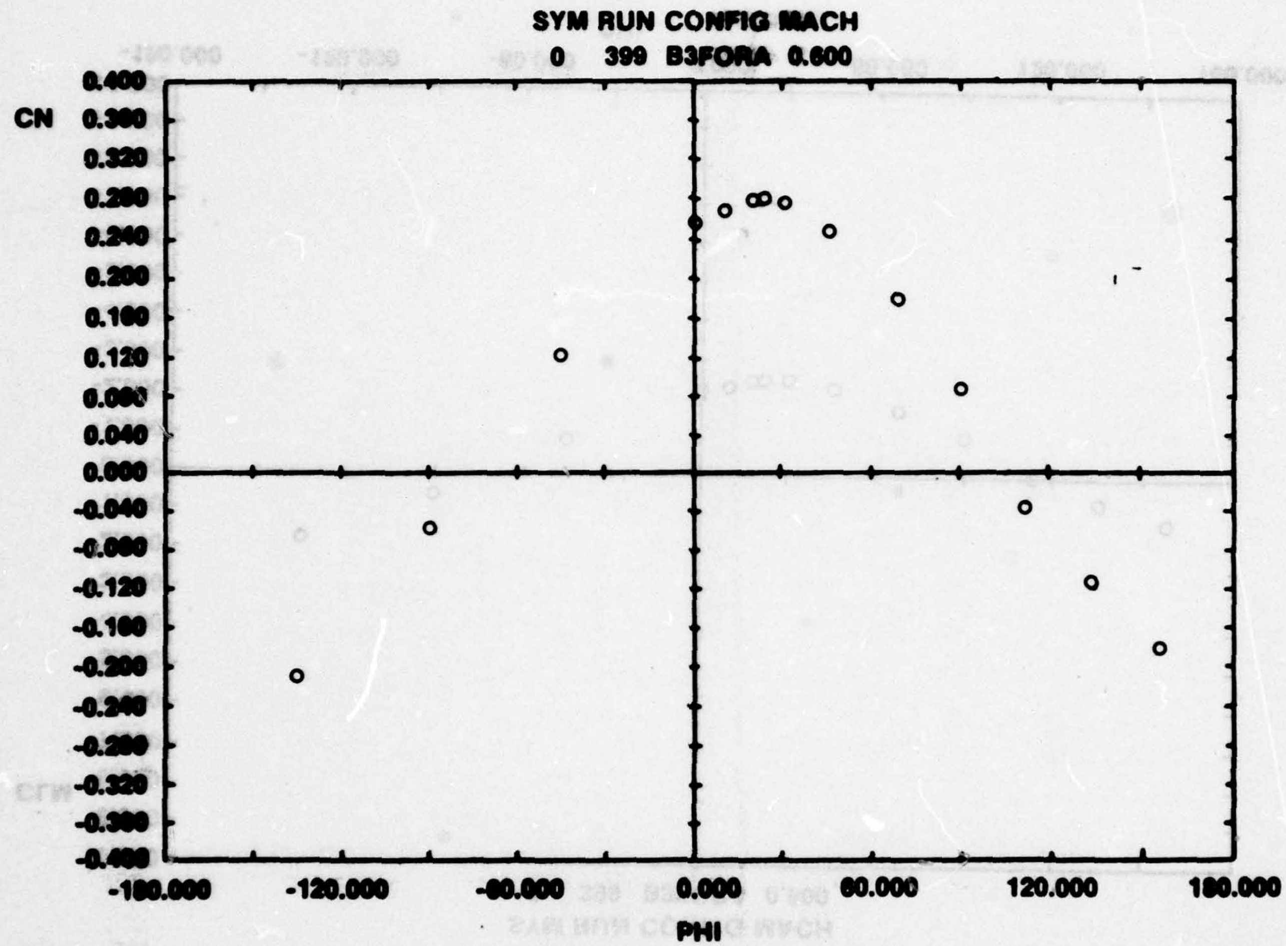


Figure 27. Alpha = 1.



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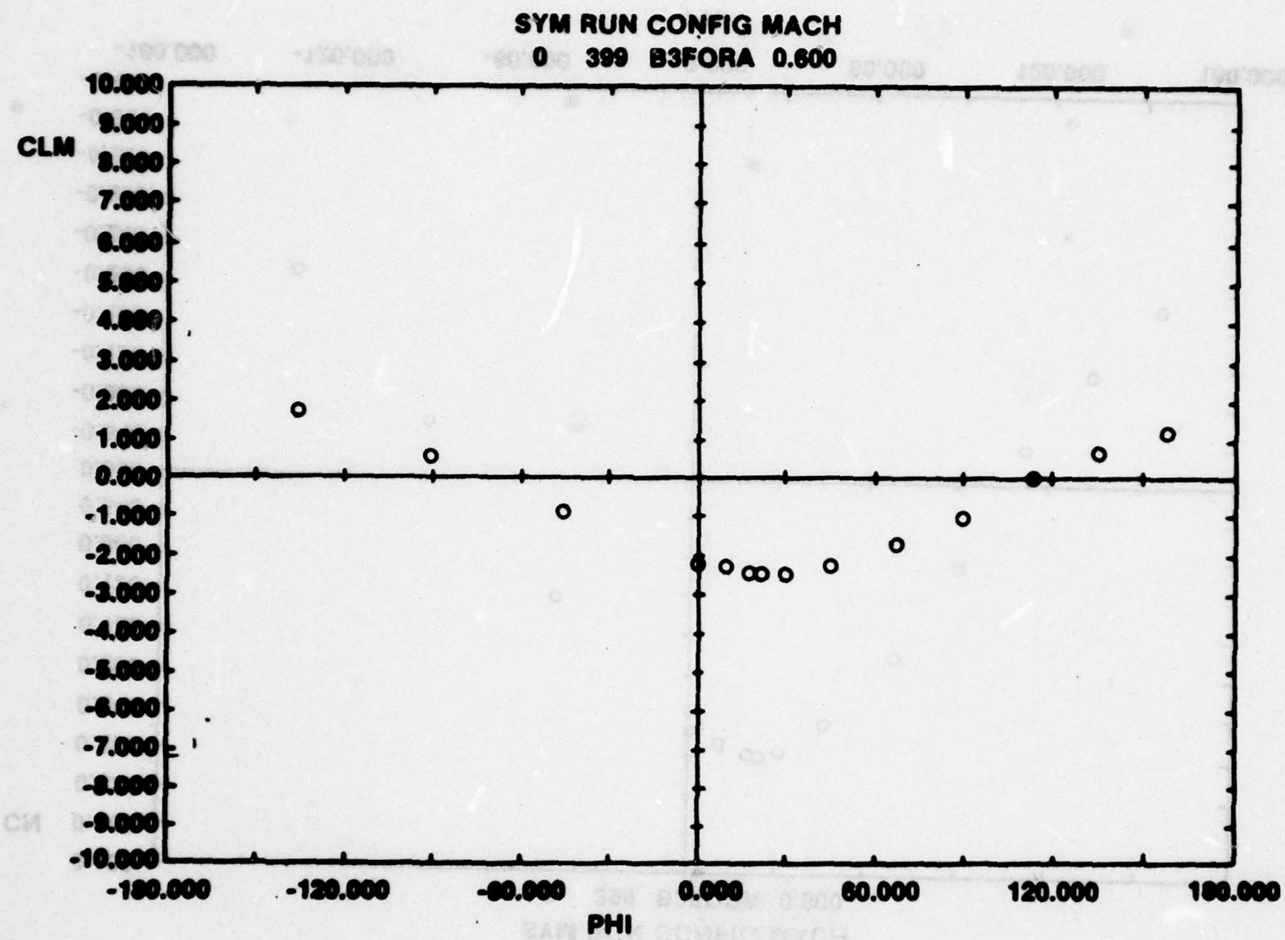

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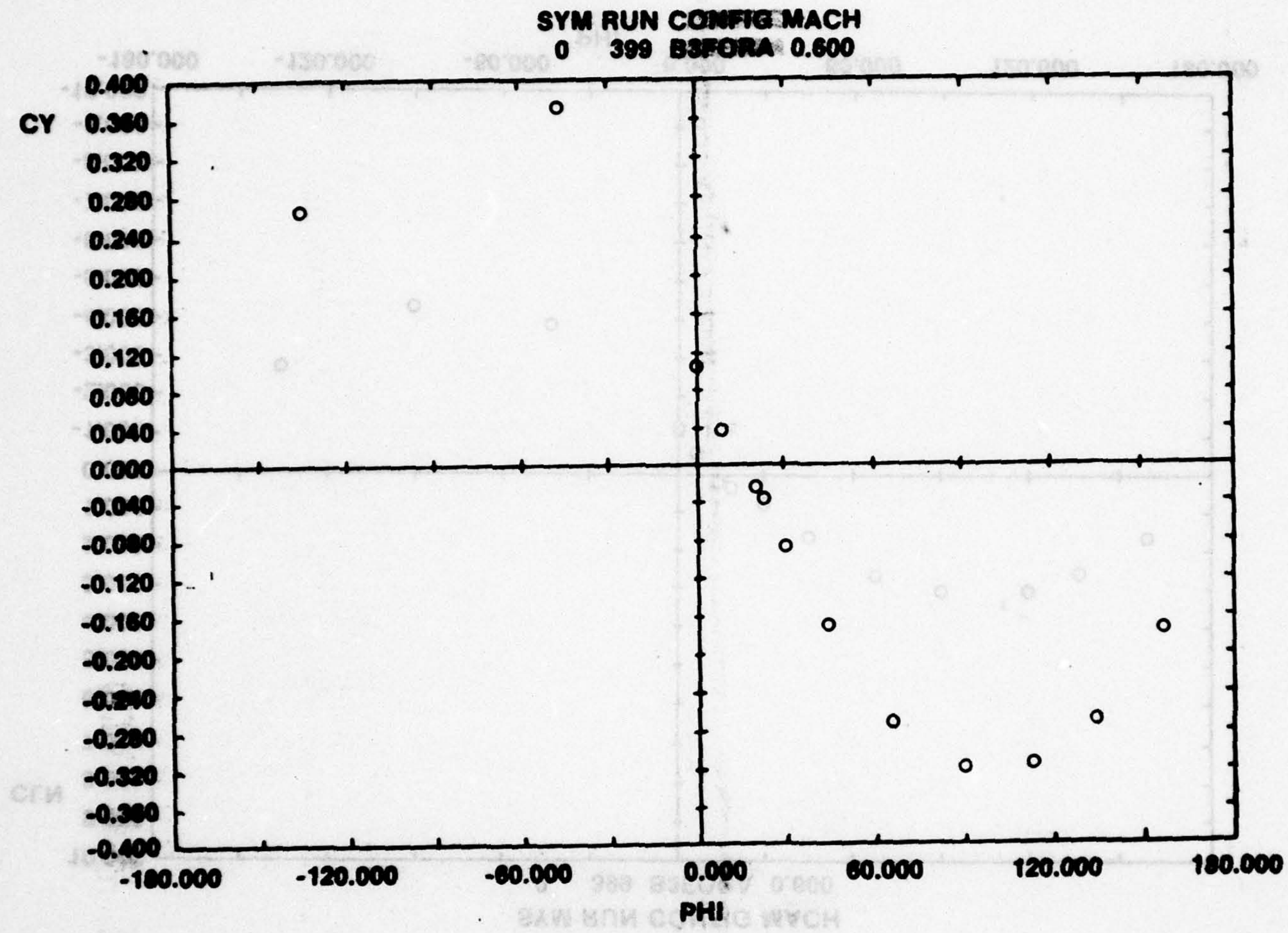

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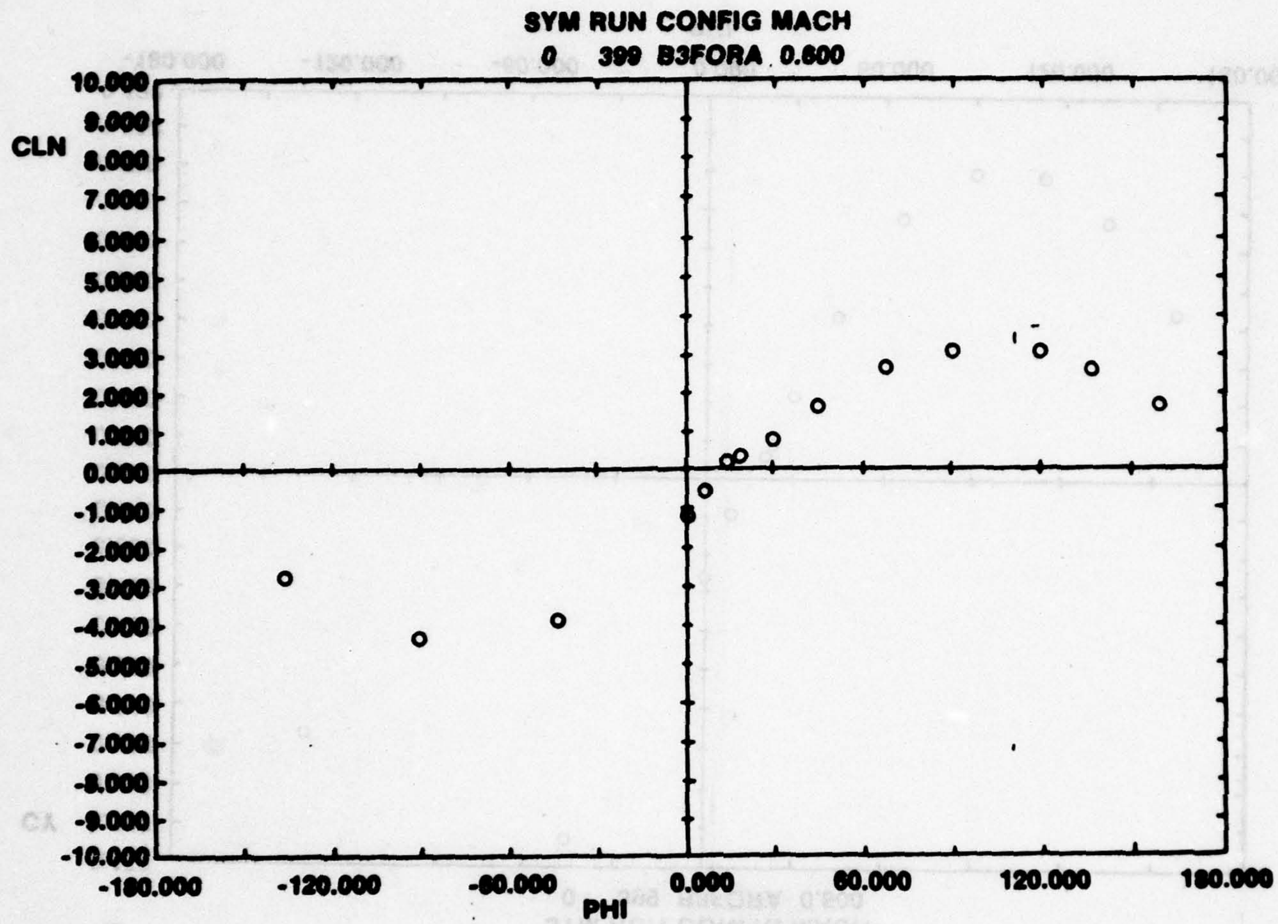

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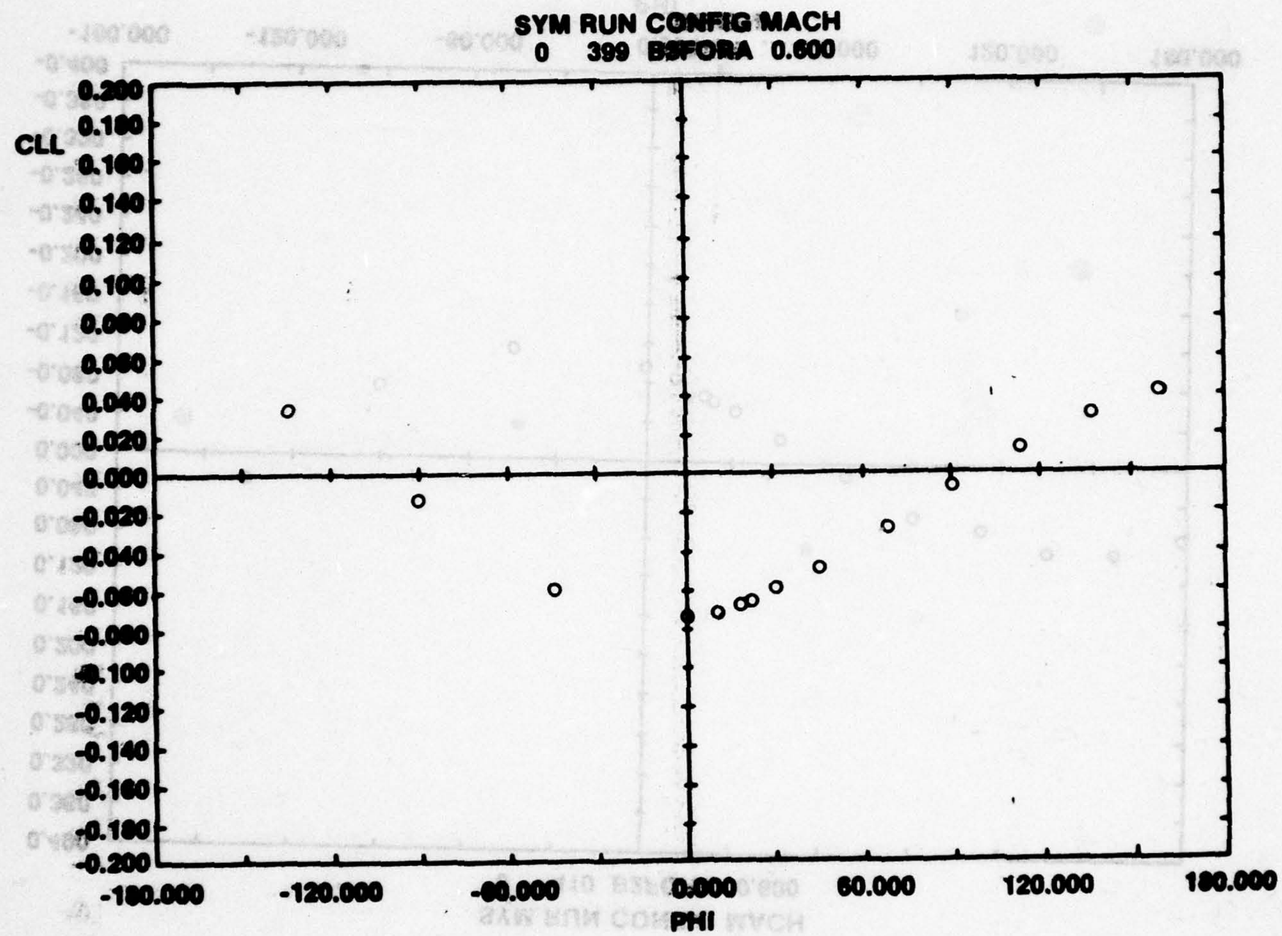

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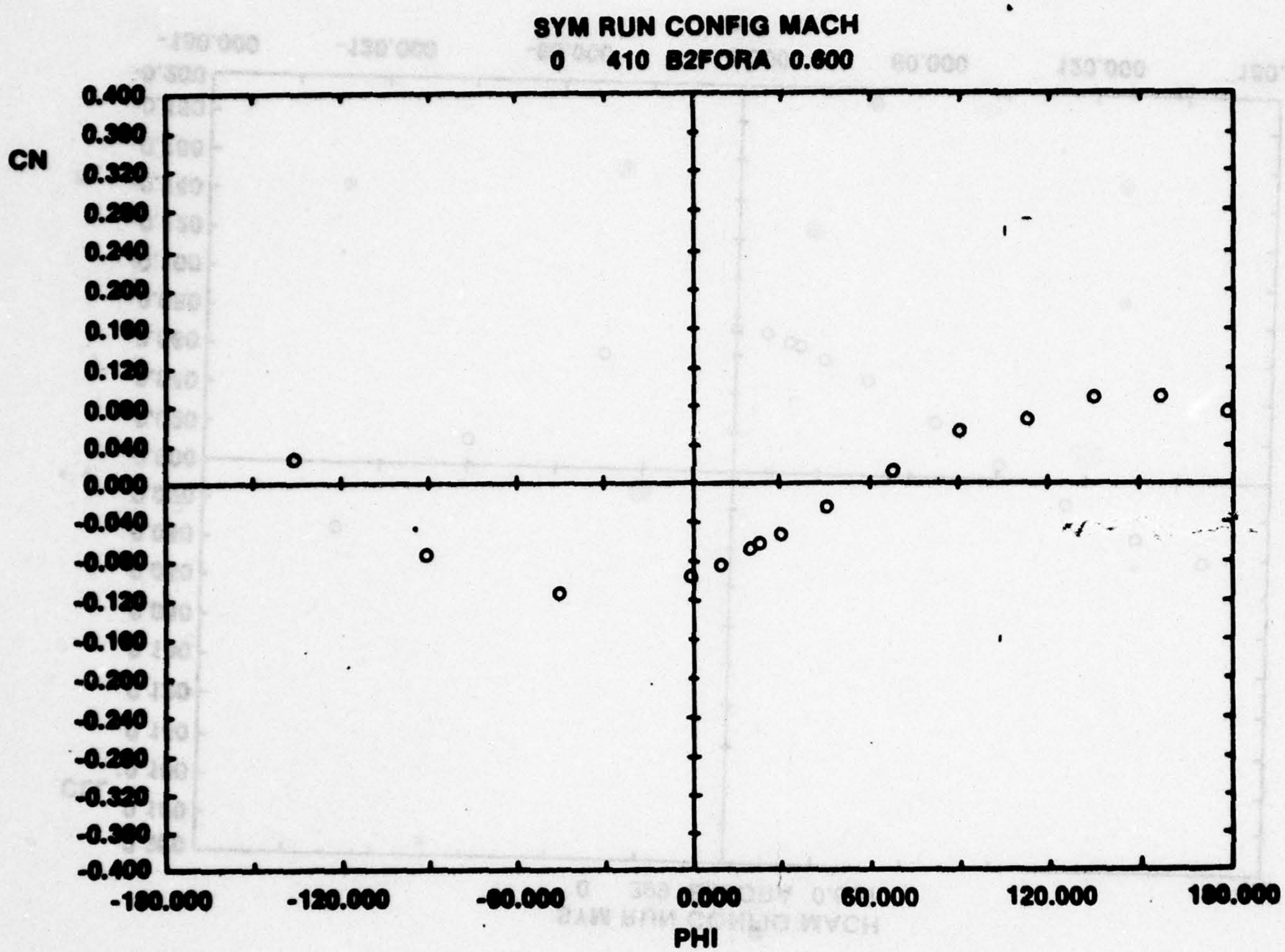

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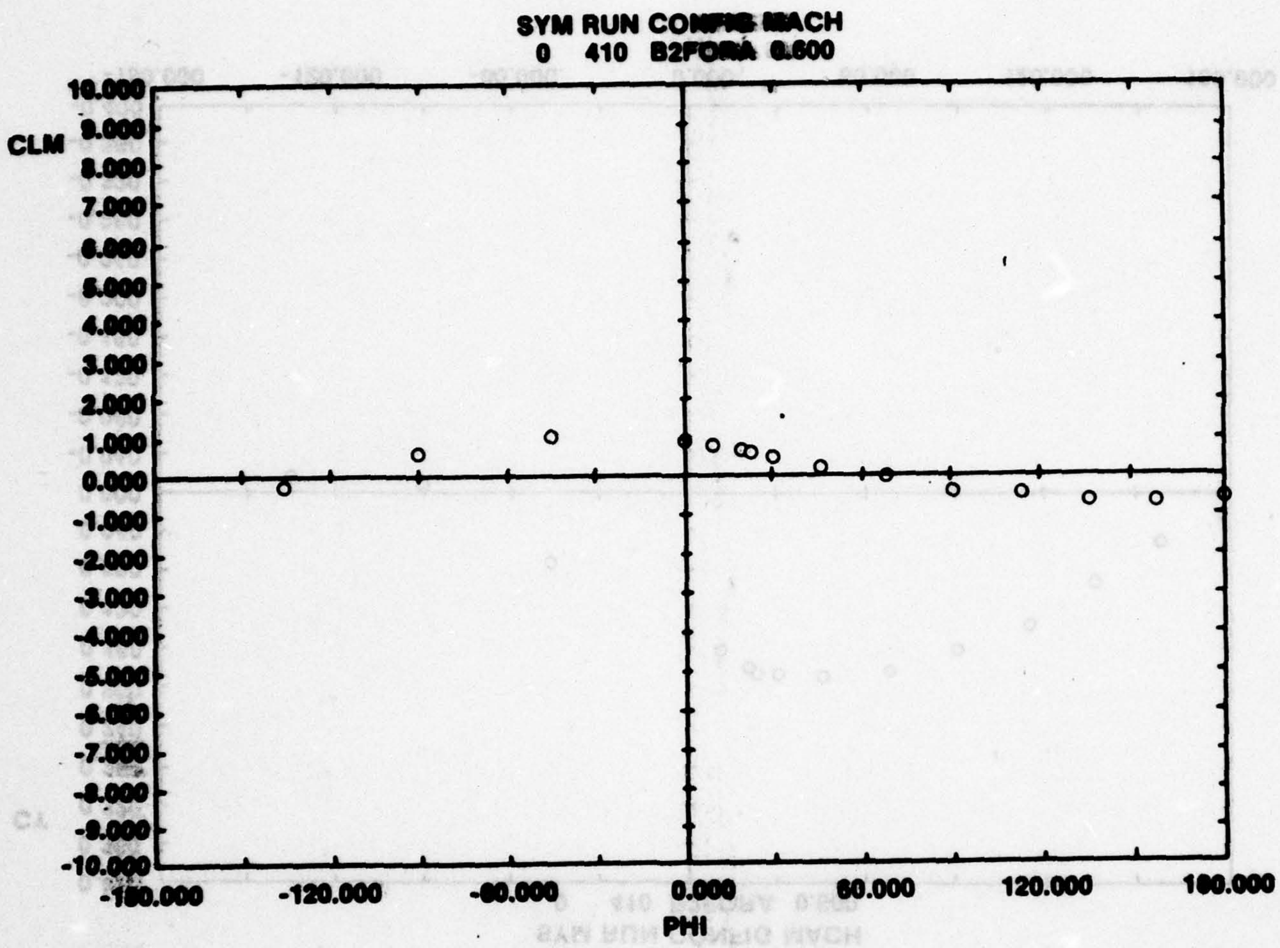

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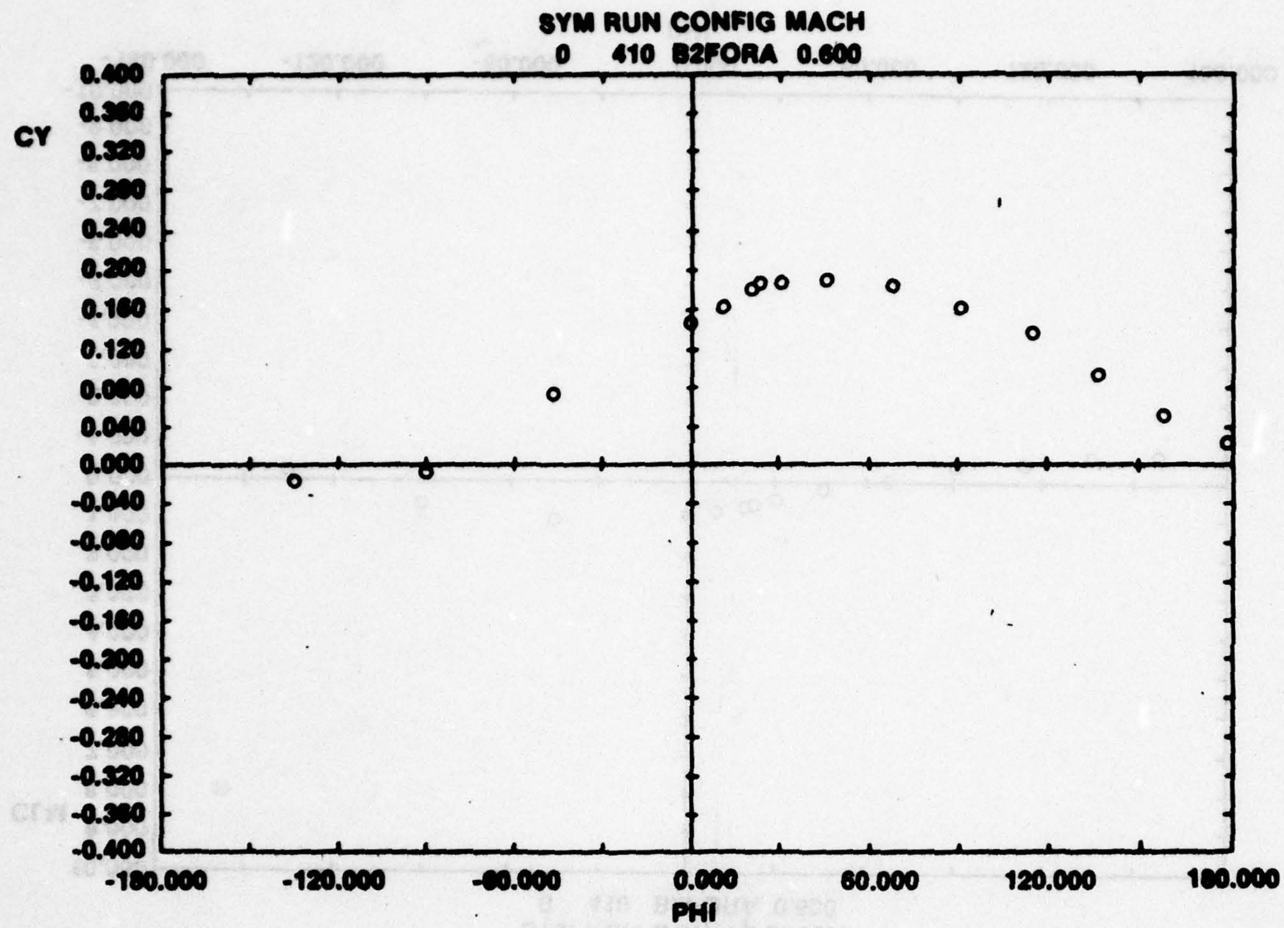

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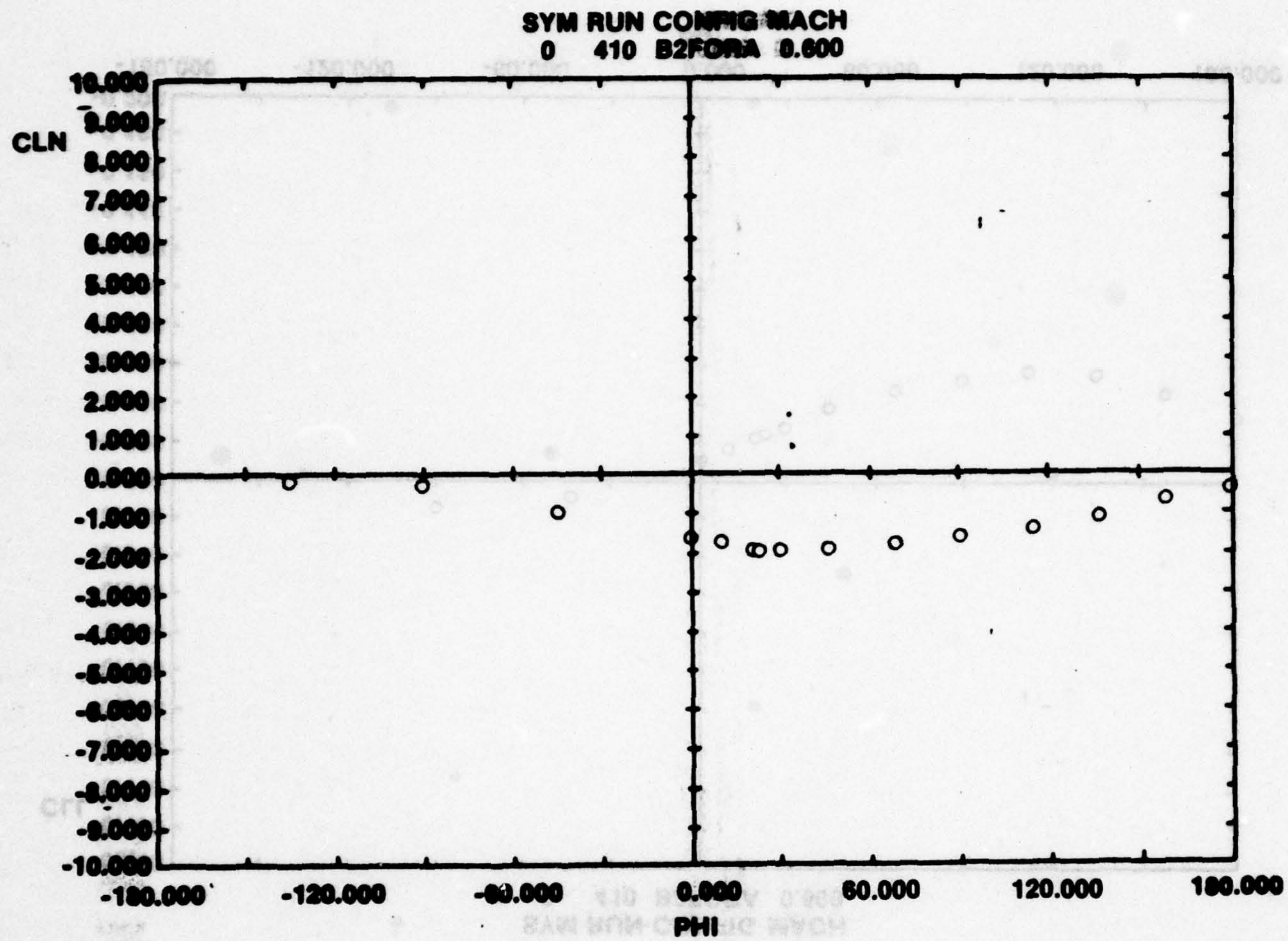

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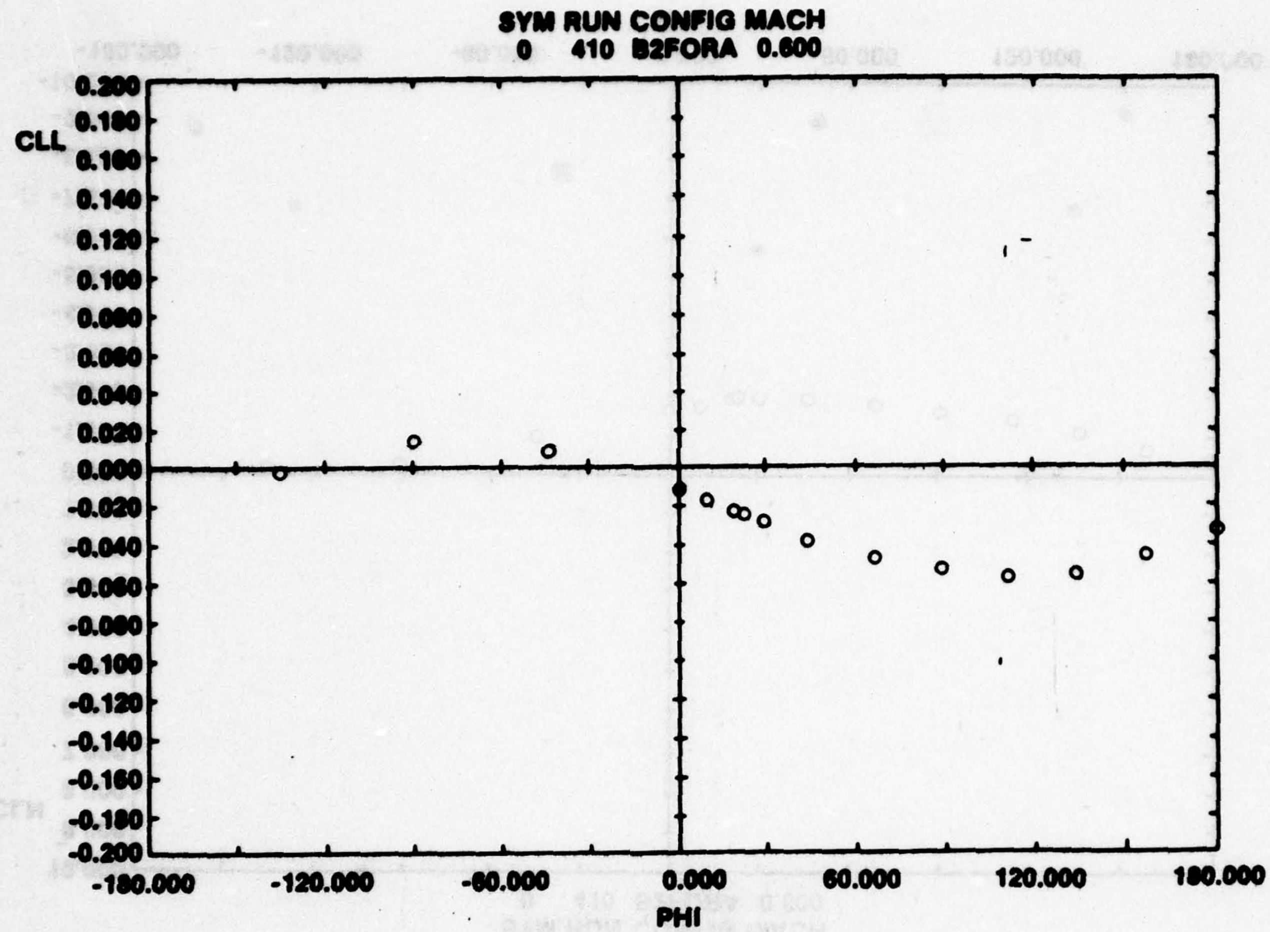

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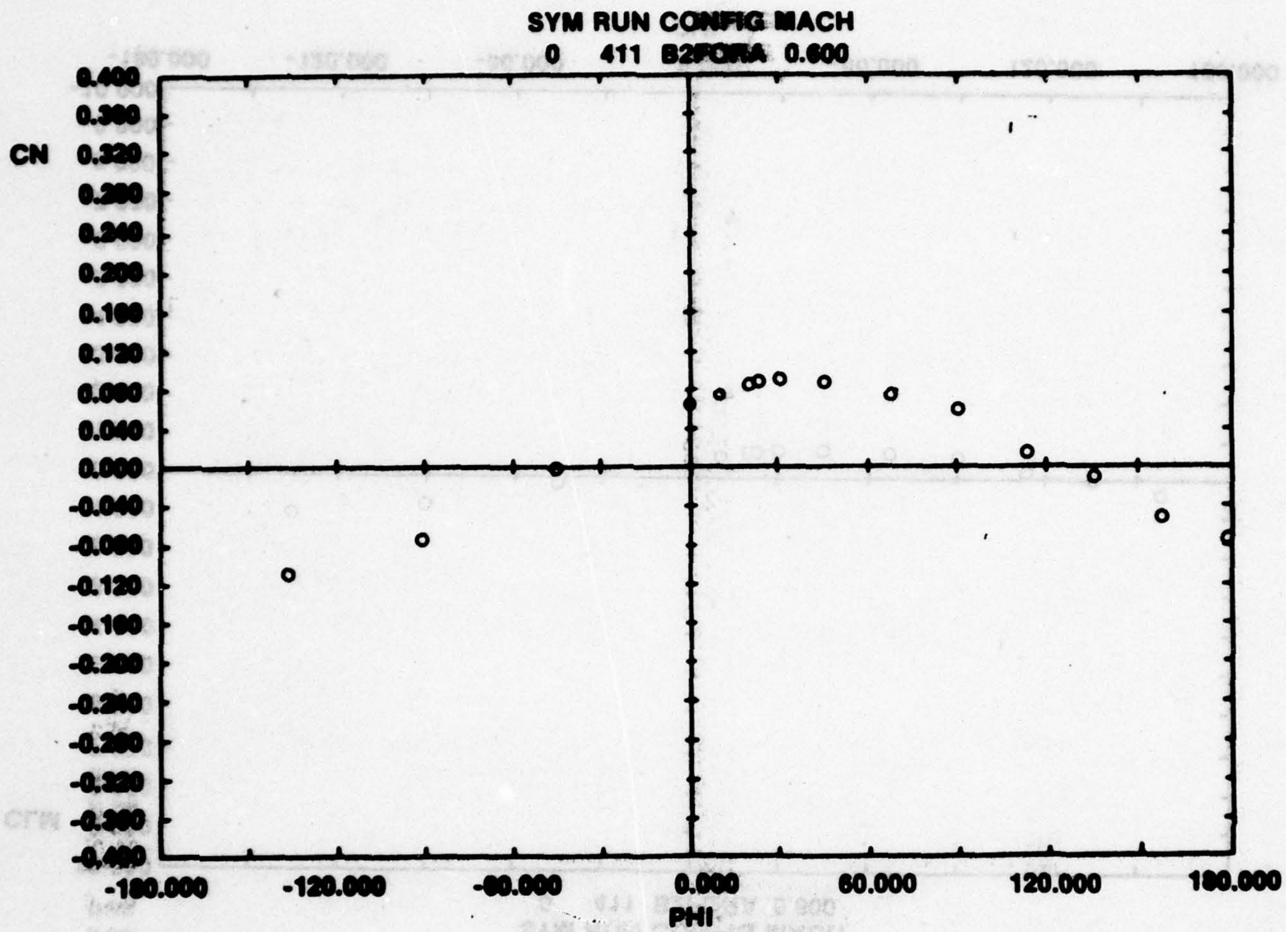

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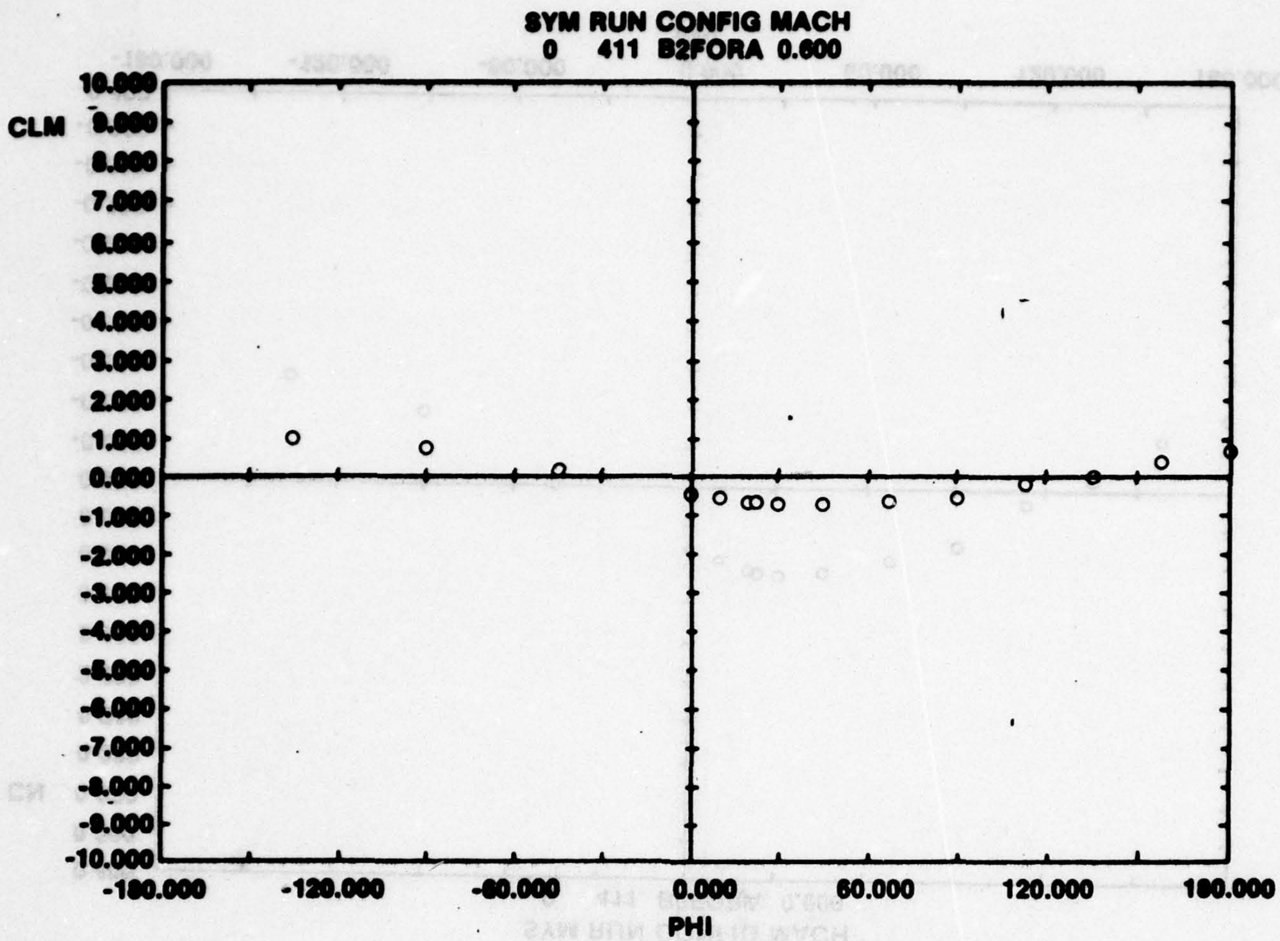

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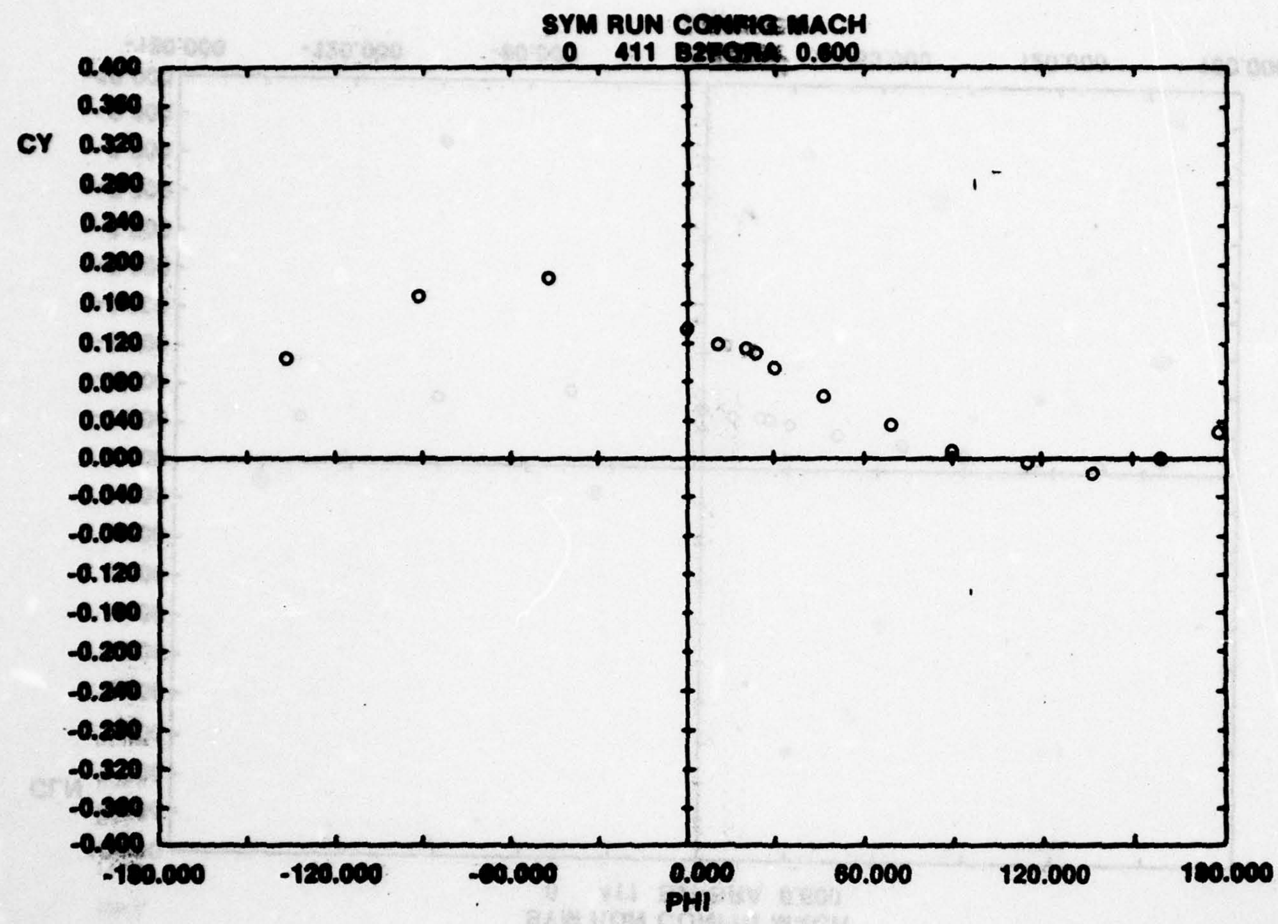

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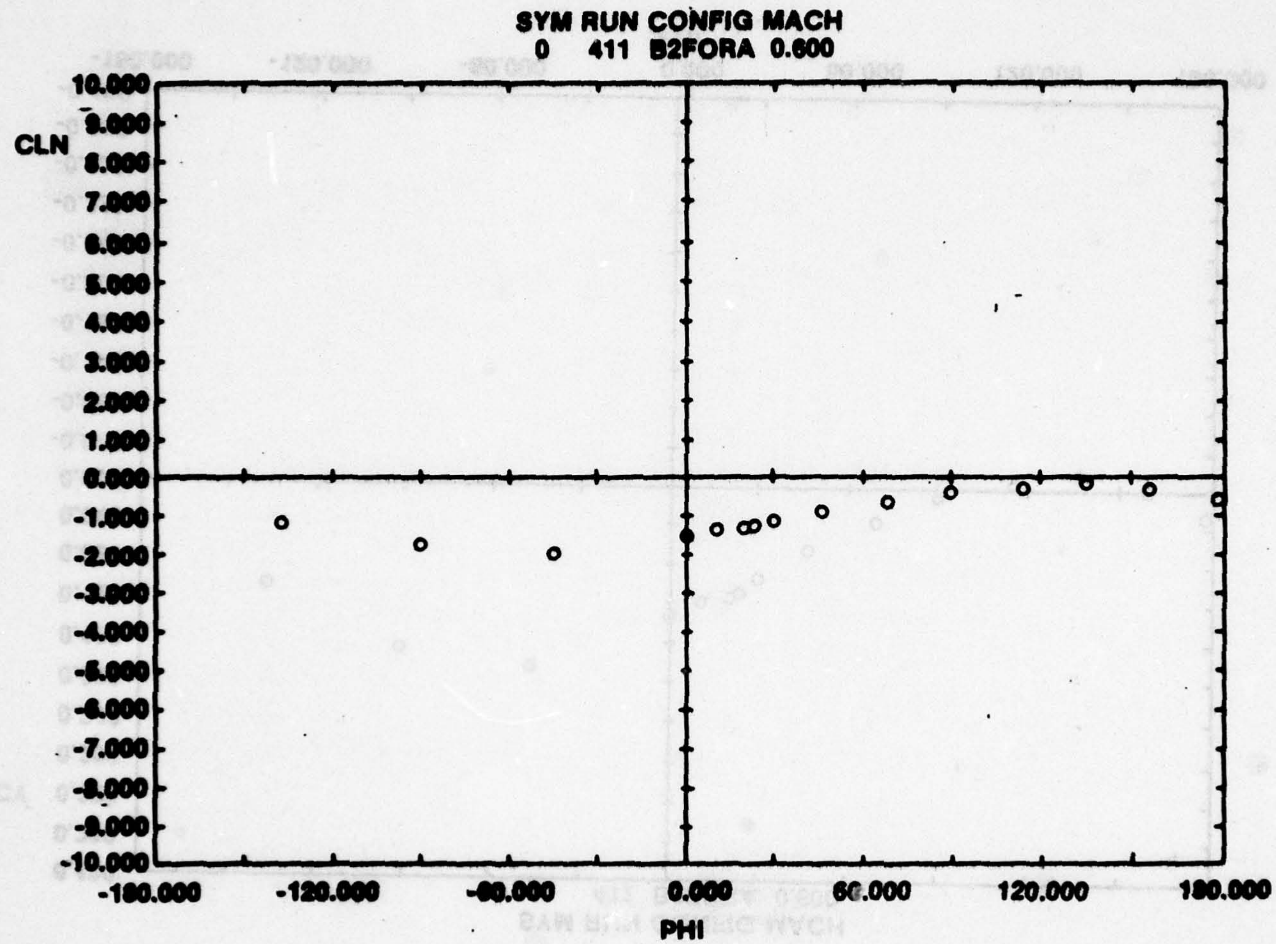

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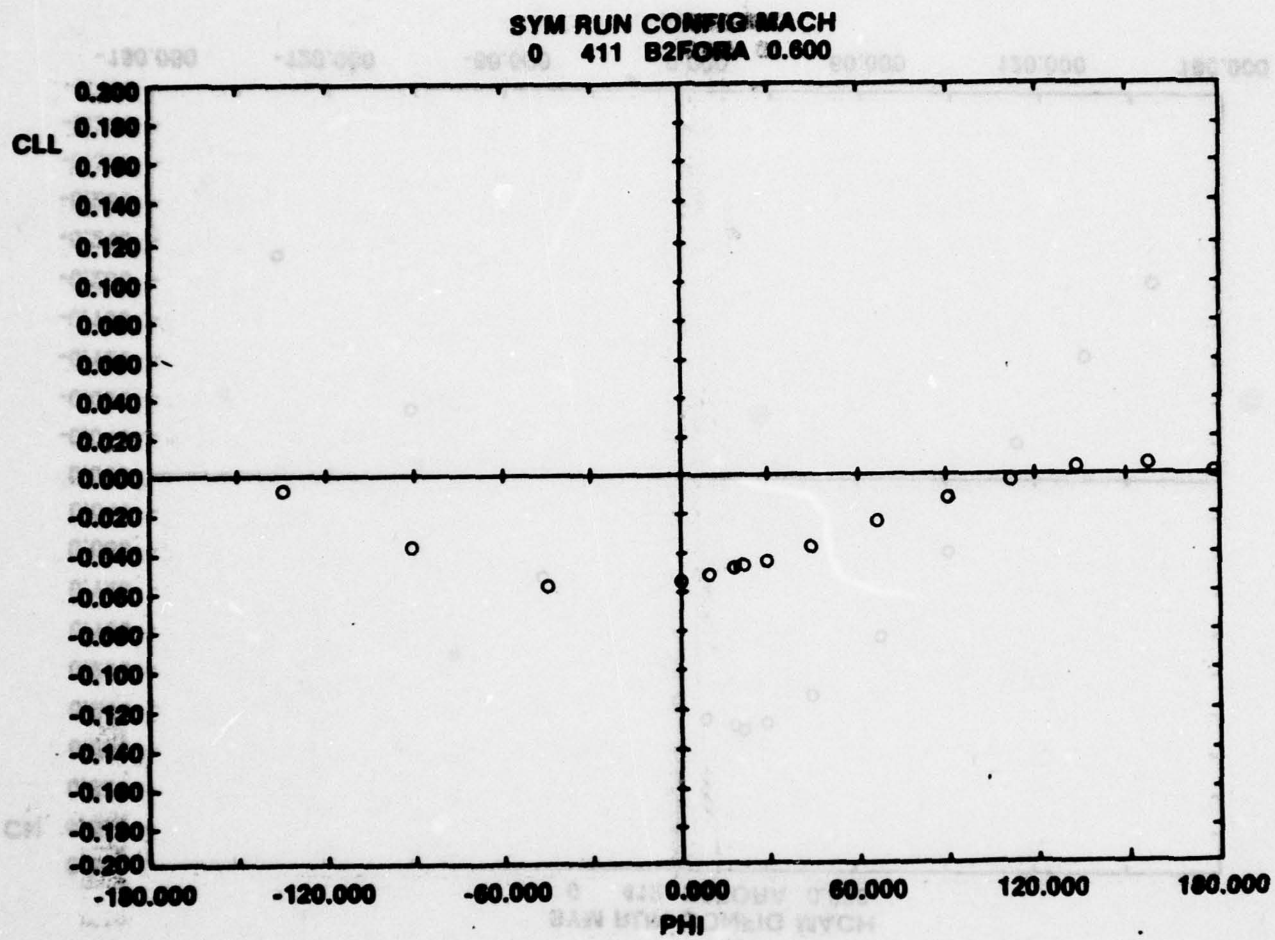

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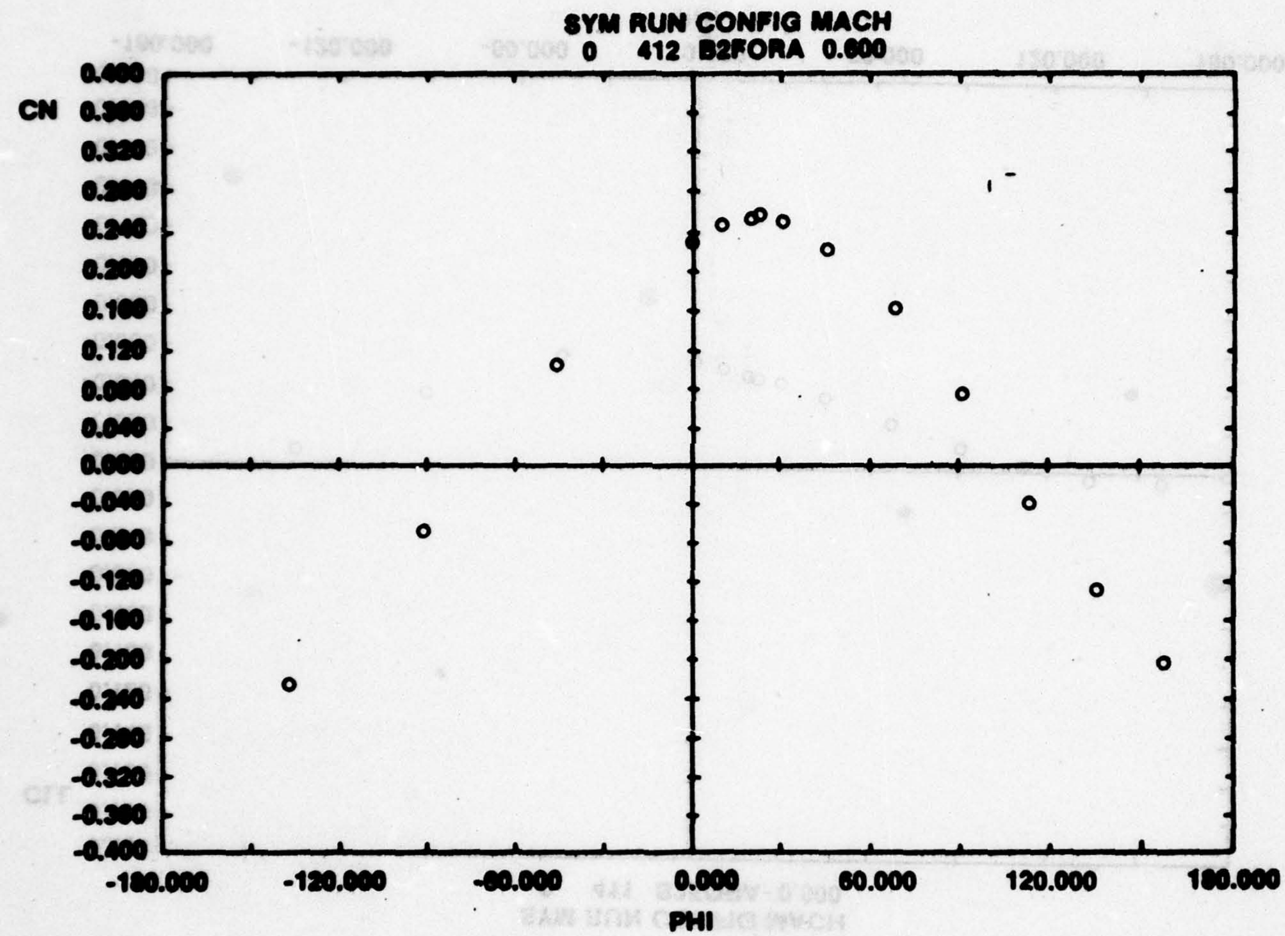

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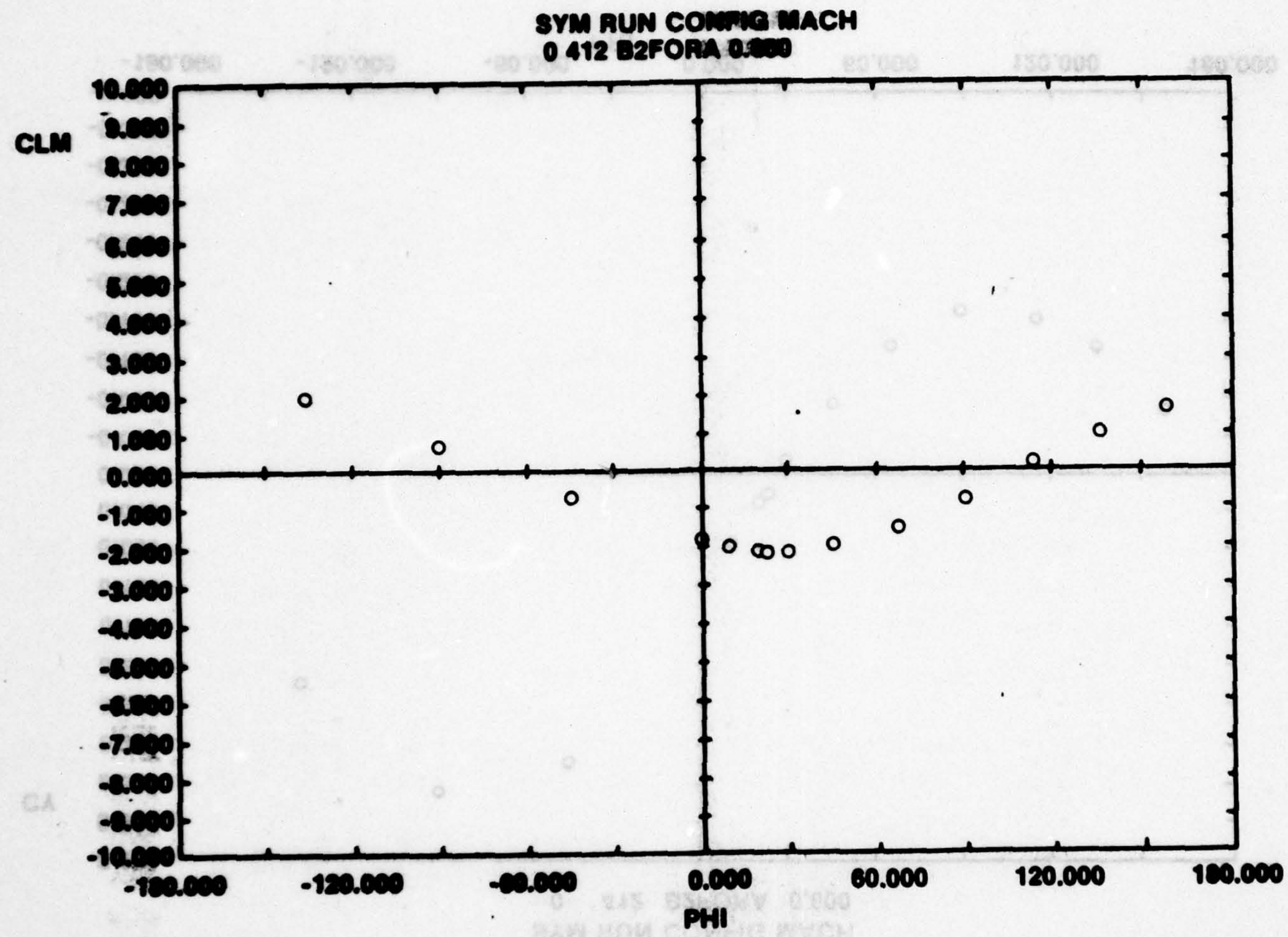

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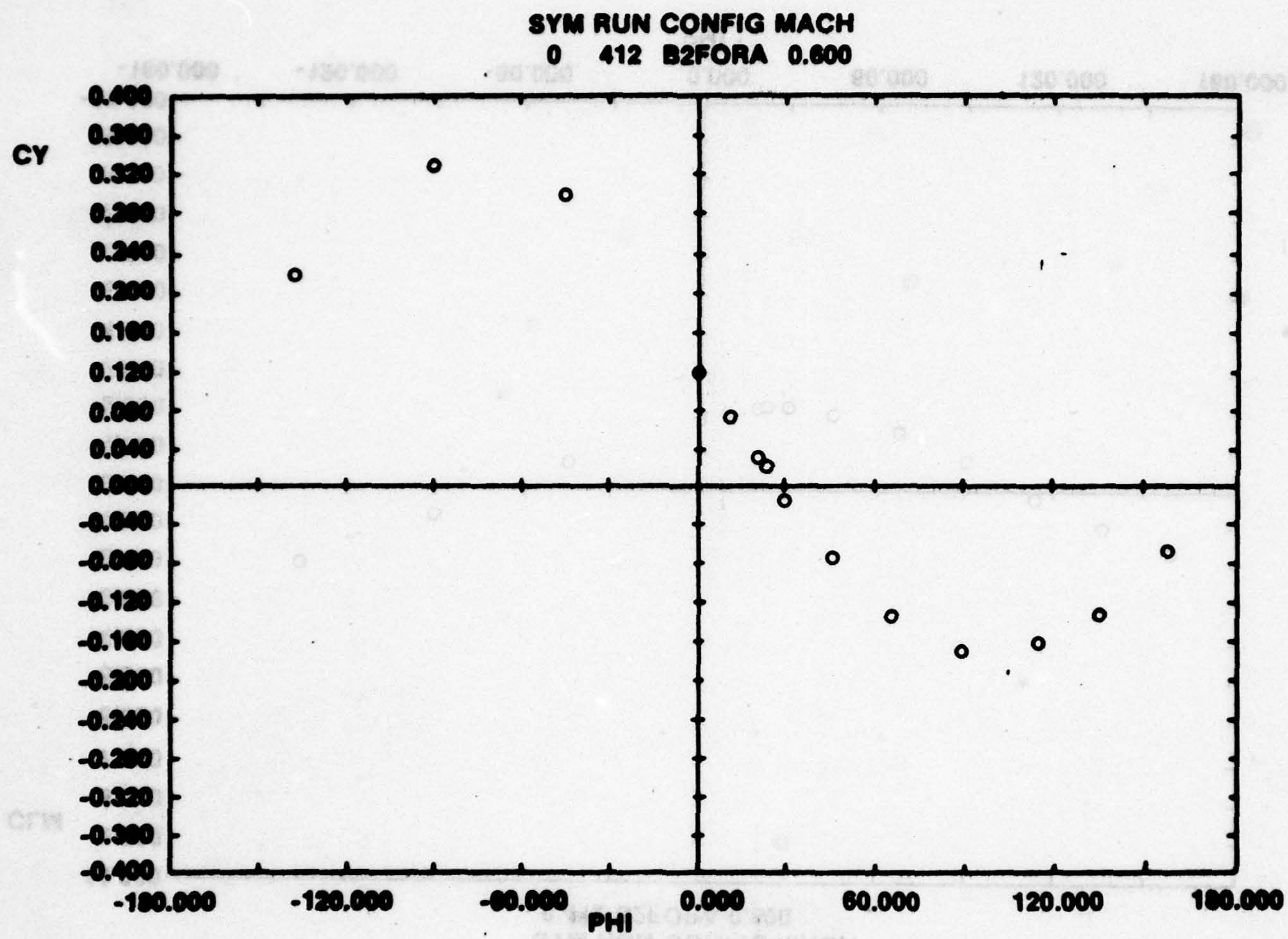

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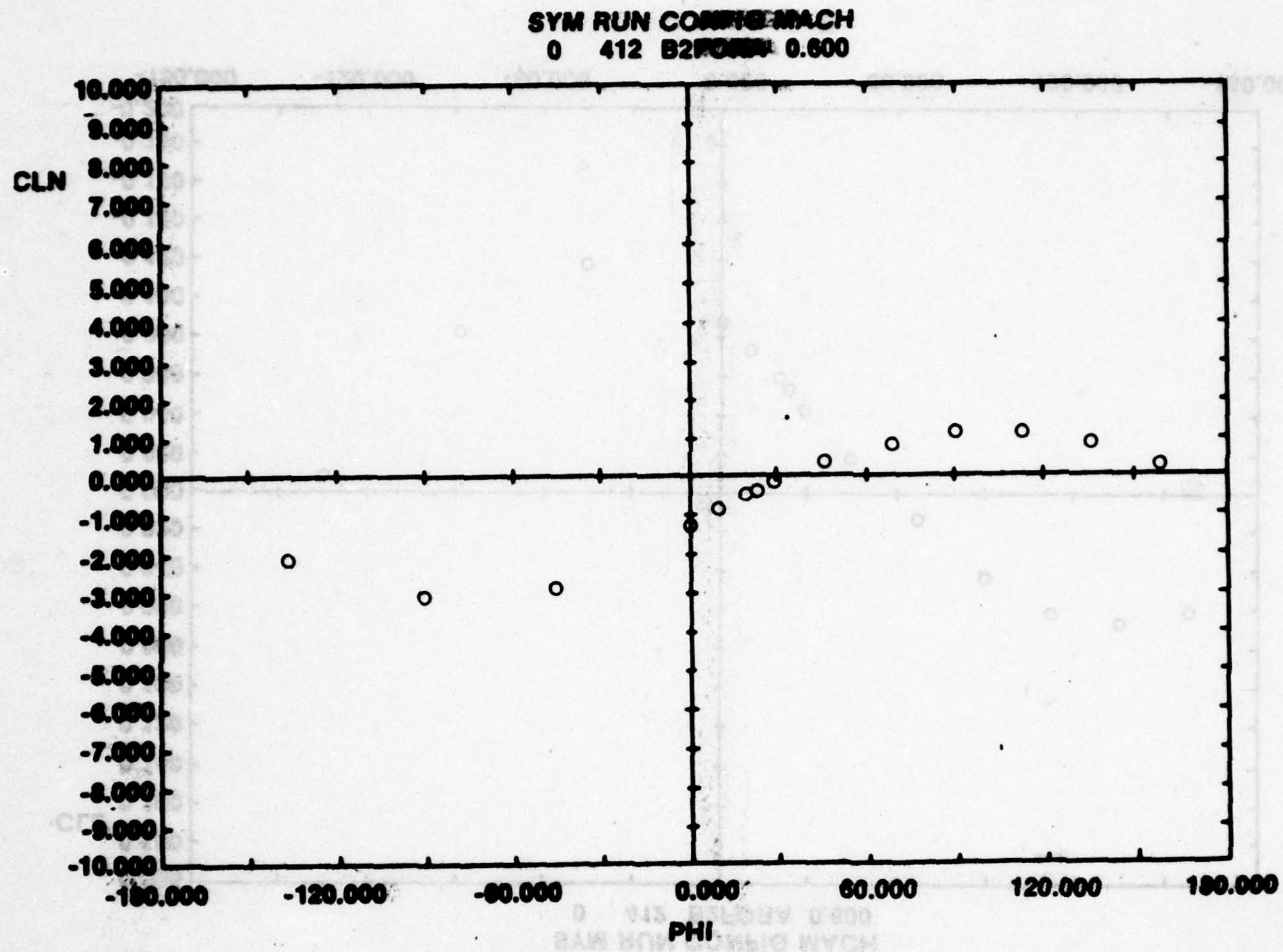

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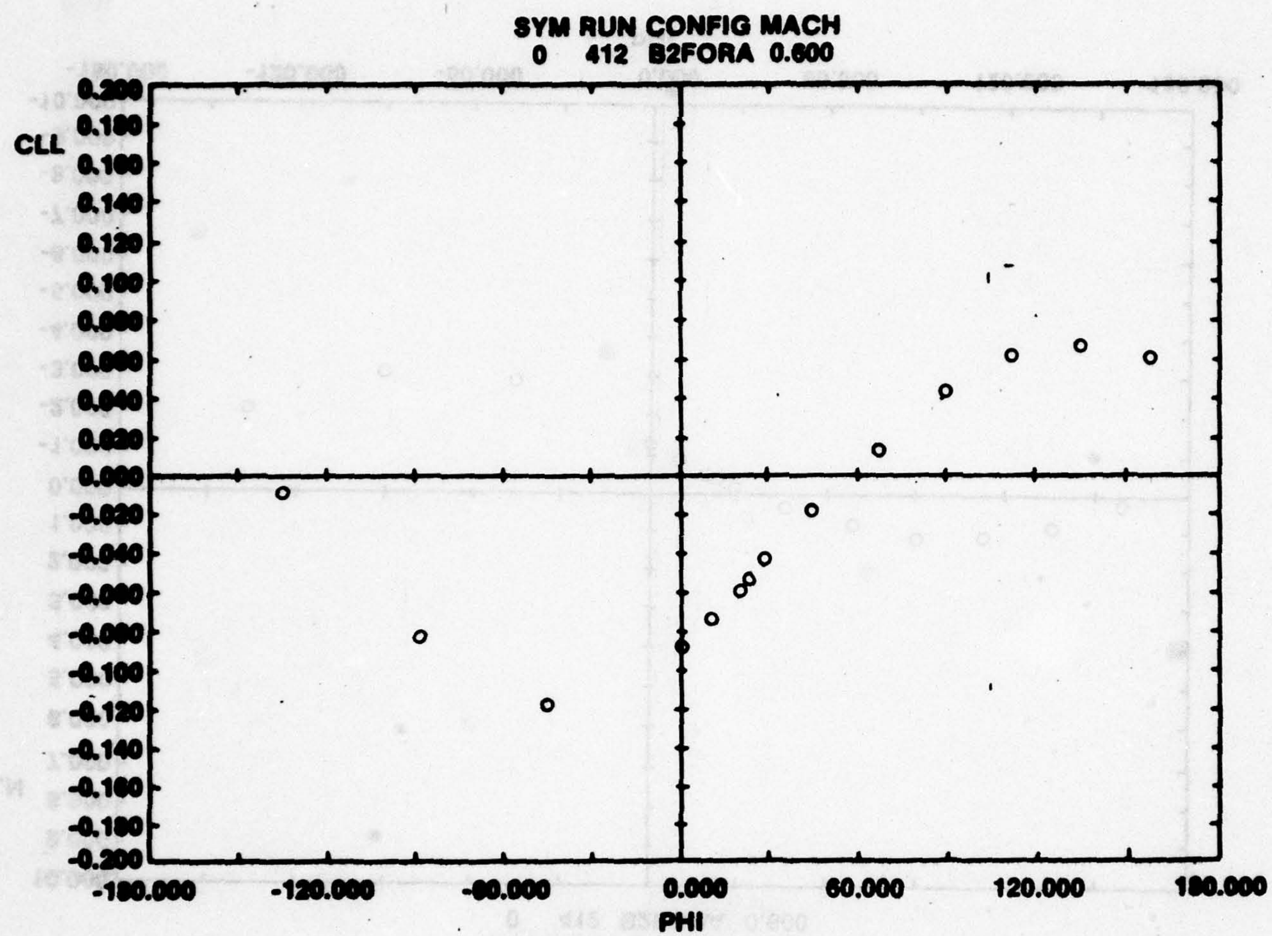


Figure 47. Alpha = 3.

REFERENCES

1 Test Facilities Handbook (Tenth Edition). Arnold Engineering Development Center, Arnold Air Force Station, Tennessee, May 1974.

2. Dahlke, C. W., The Aerodynamic Characteristics of Wraparound Fins at Mach Numbers of 0.3 to 3.0, US Army Missile Command, Redstone Arsenal, Alabama, Report No. RD-77-4.

3. Gafarian, A. F., and Phillips, W.L., The Supersonic Lift and Centers of Pressure of Rectangular and Clipped Delta Fins in Combination With Long Cylindrical Bodies, US Naval Ordnance Test Station, China Lake, California, Report No. TM-966, 1963.

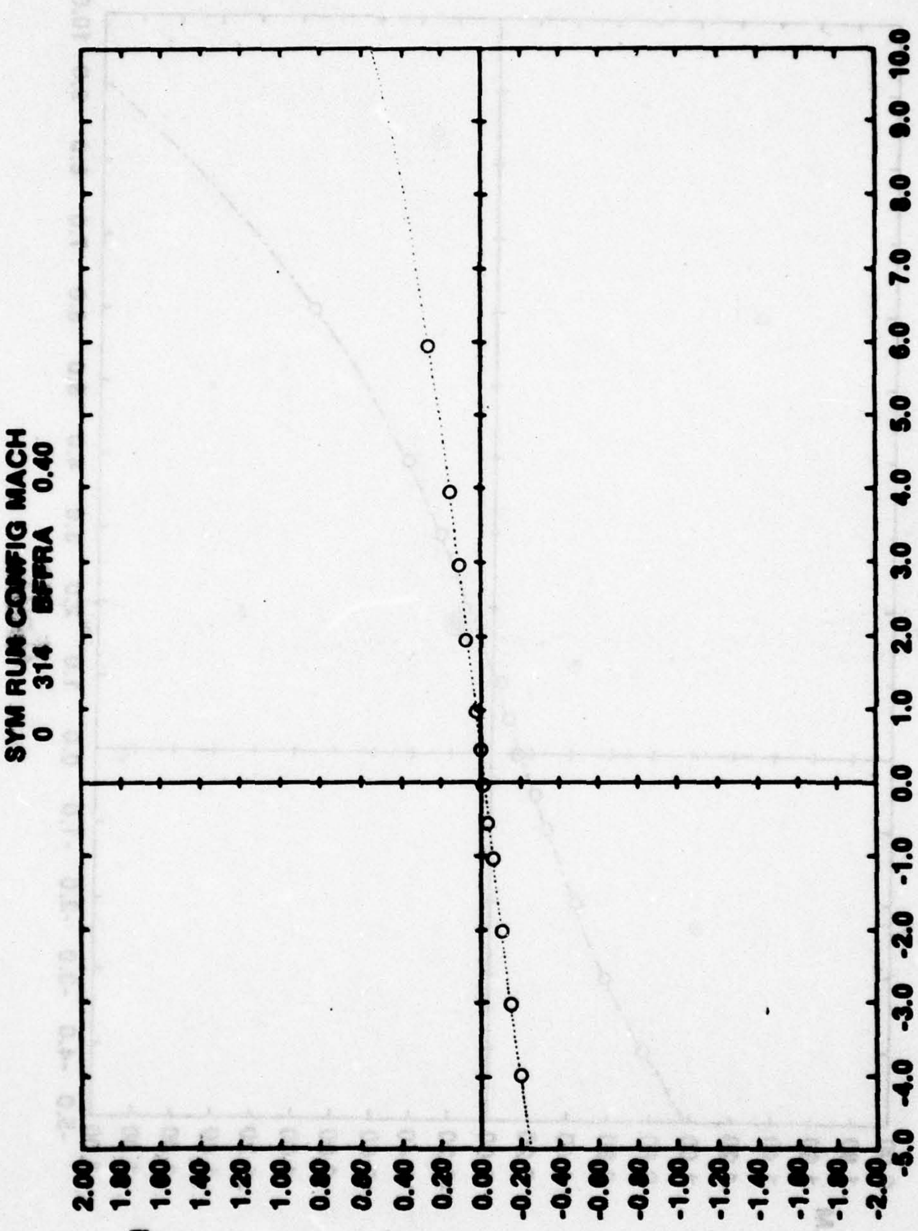
4. McDevitt, John B., A Correlation by Means of Transonic Similarity Rules of Experimentally Determined Characteristics of a Series of Symmetrical and Cambered Wings of Rectangular Plan Form, National Advisory Committee for Aeronautics, Washington, D. C., NACA Report 1253, 1955.

5. Pitts, William C.; Nielson, Jack N.; and Kattari, George E., Lift and Center of Pressure of Wing-Body-Tail Combinations at Subsonic, Transonic, and Supersonic Speeds, National Advisory Committee for Aeronautics, Washington, D. C., NACA Report 1307, 1959.

6. Washington, W. D., Boattail Effects on Static Stability at Small Angles of Attack, US Army Missile Command, Redstone Arsenal, Alabama, Report No. RD-TM-68-5.

Appendix A

Basic Main Balance Data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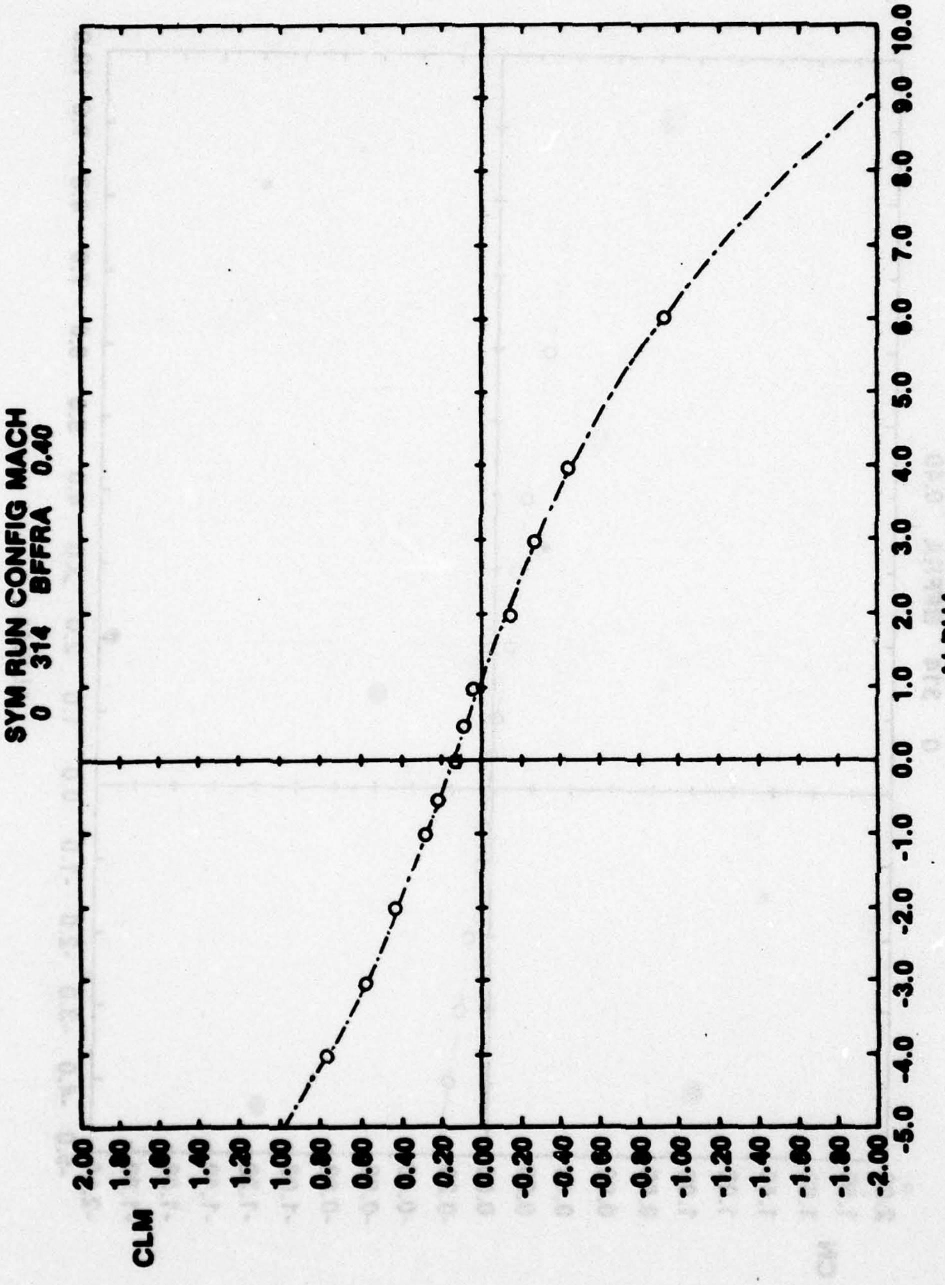
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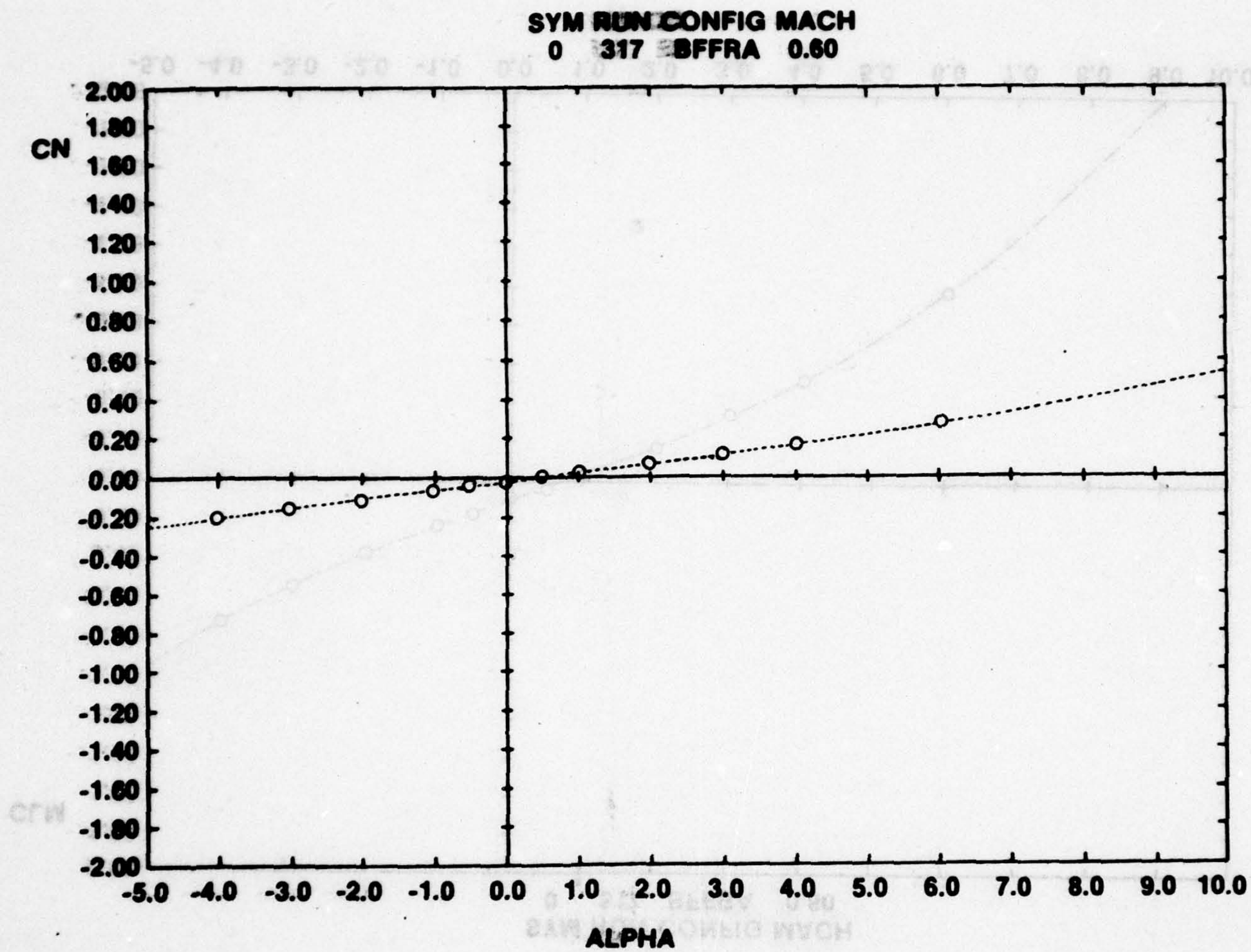
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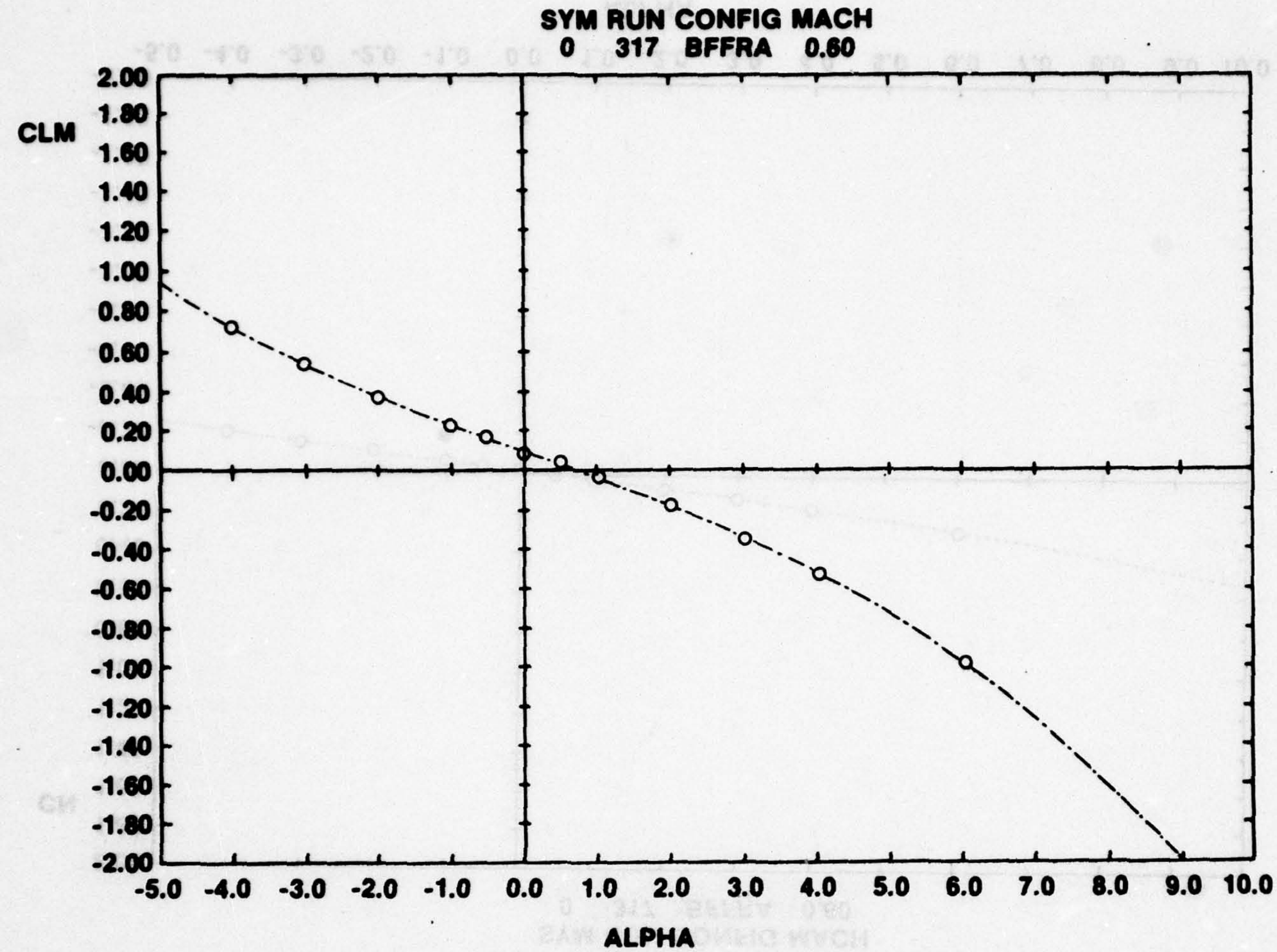
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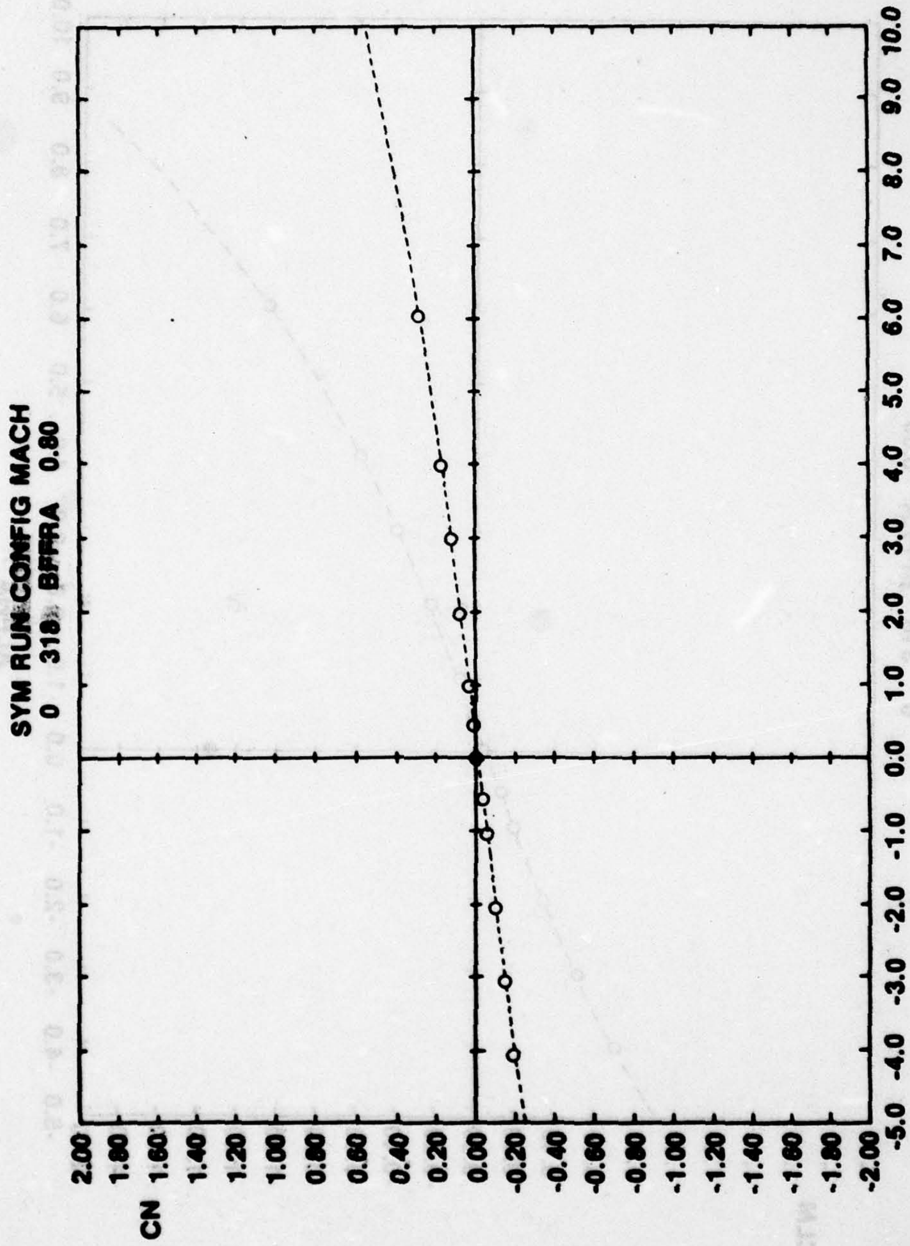
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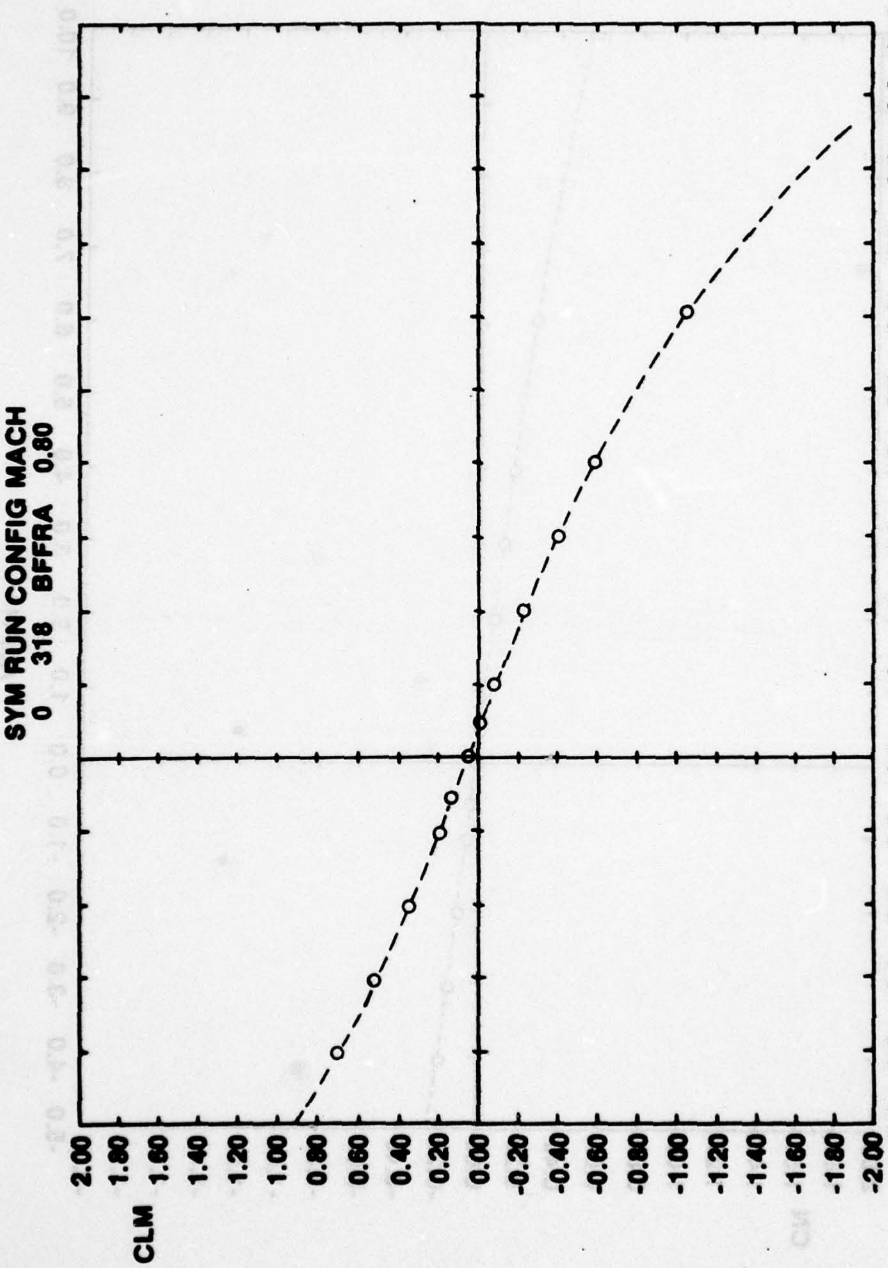
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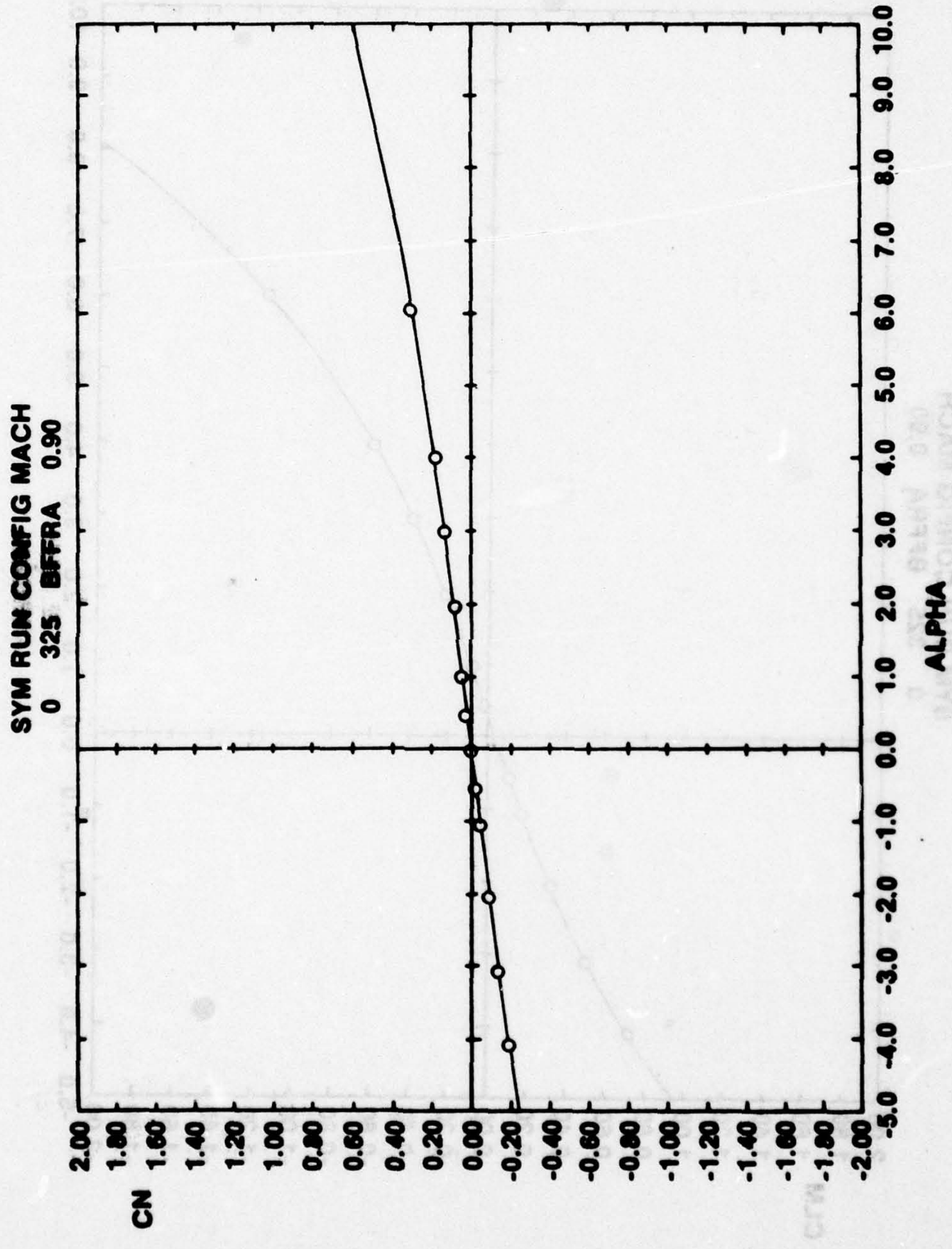
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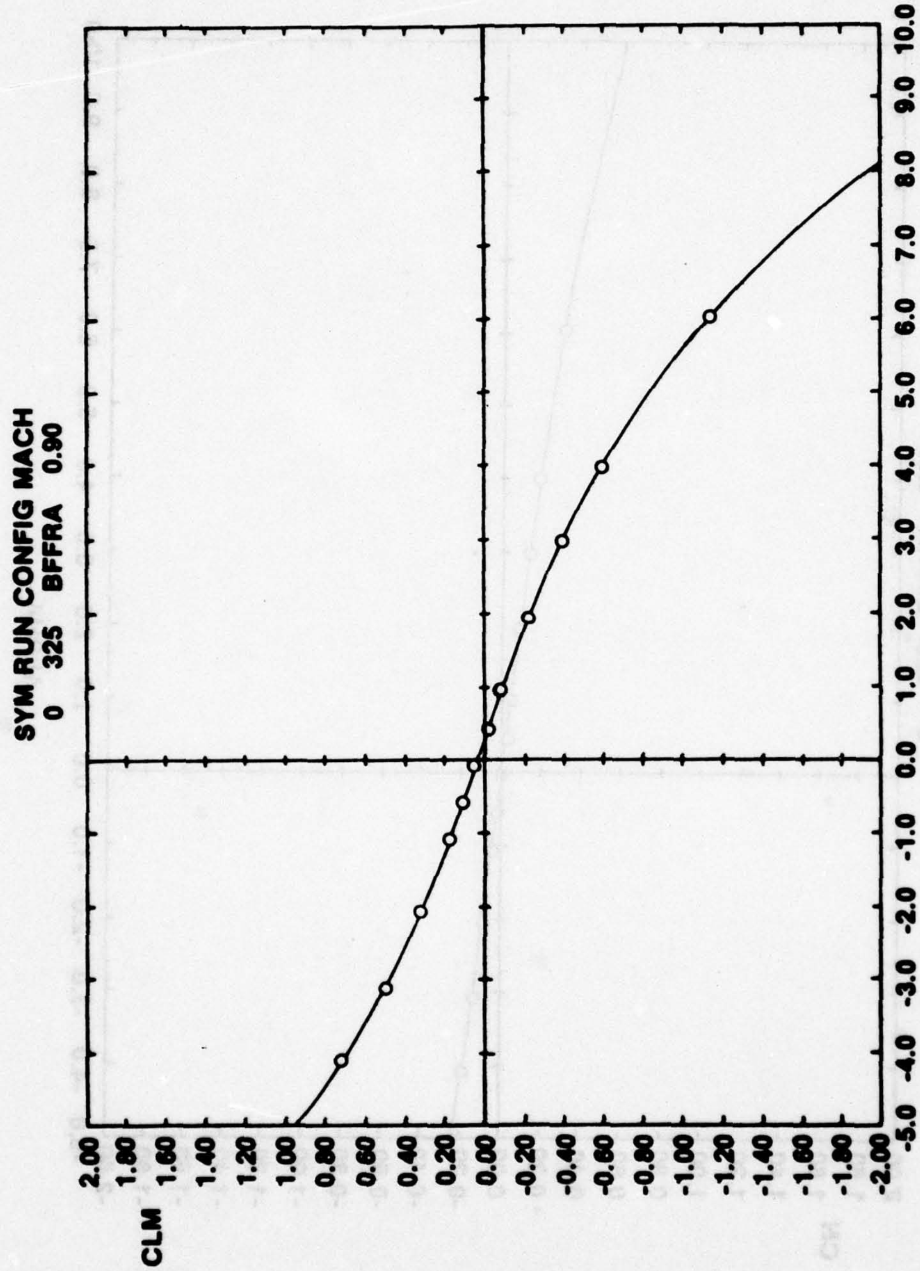
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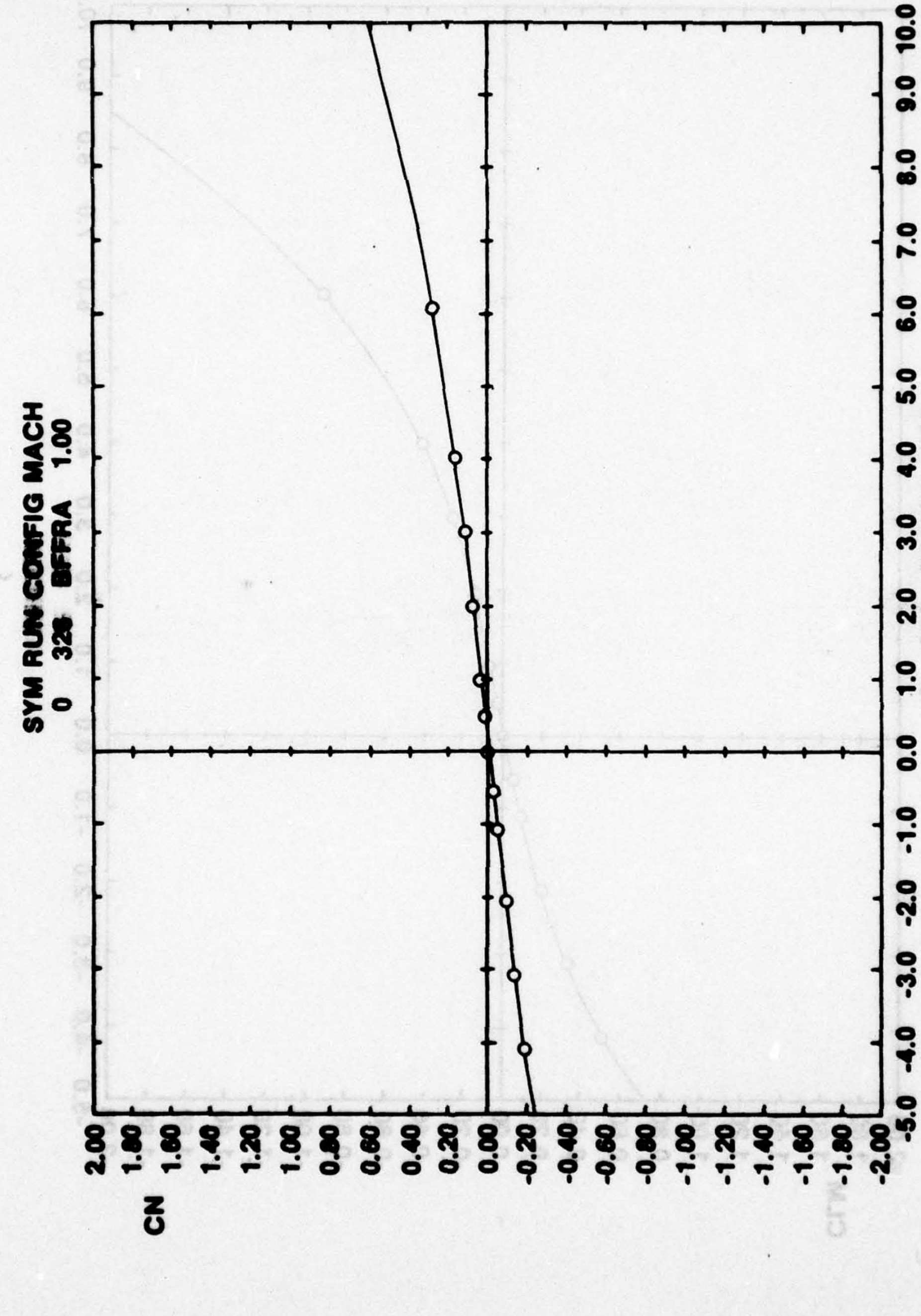
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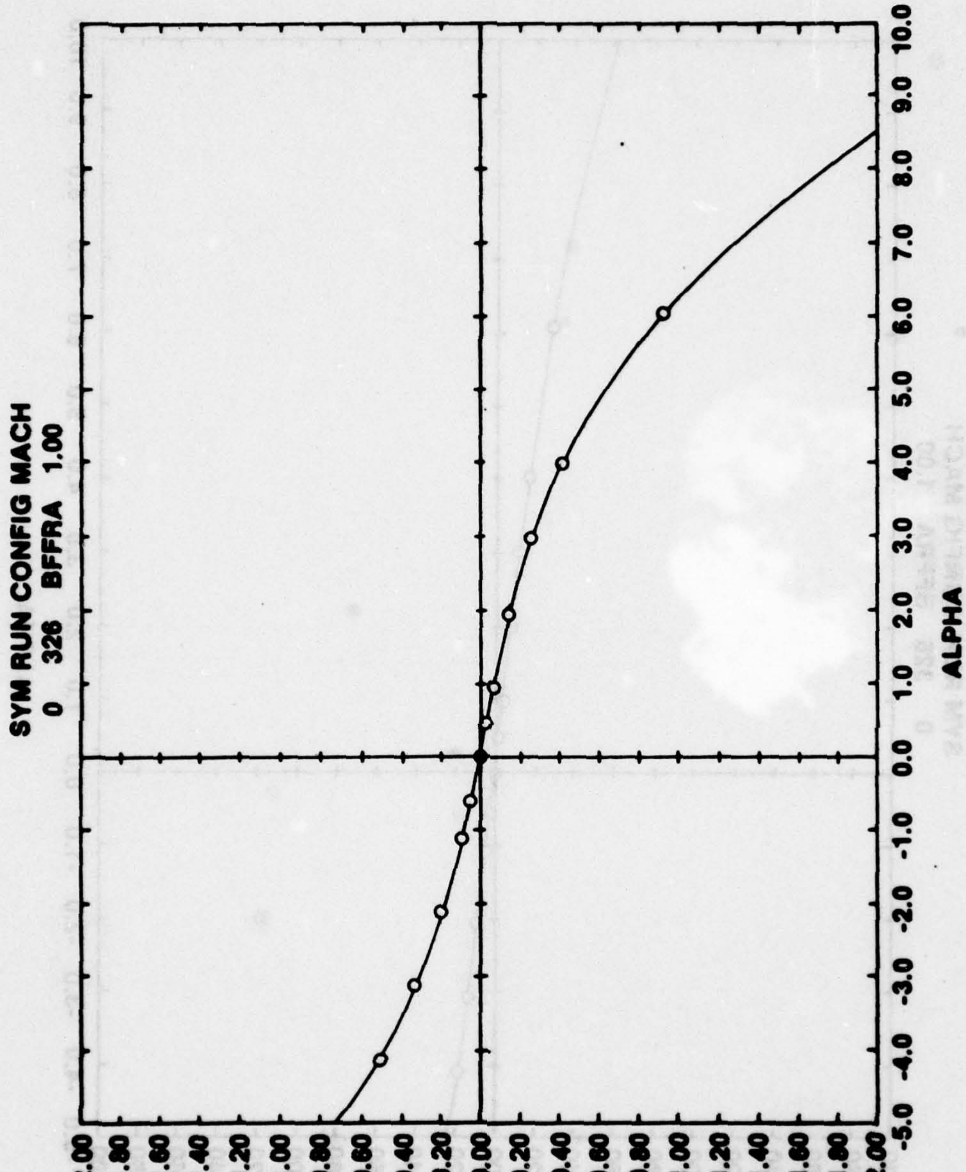
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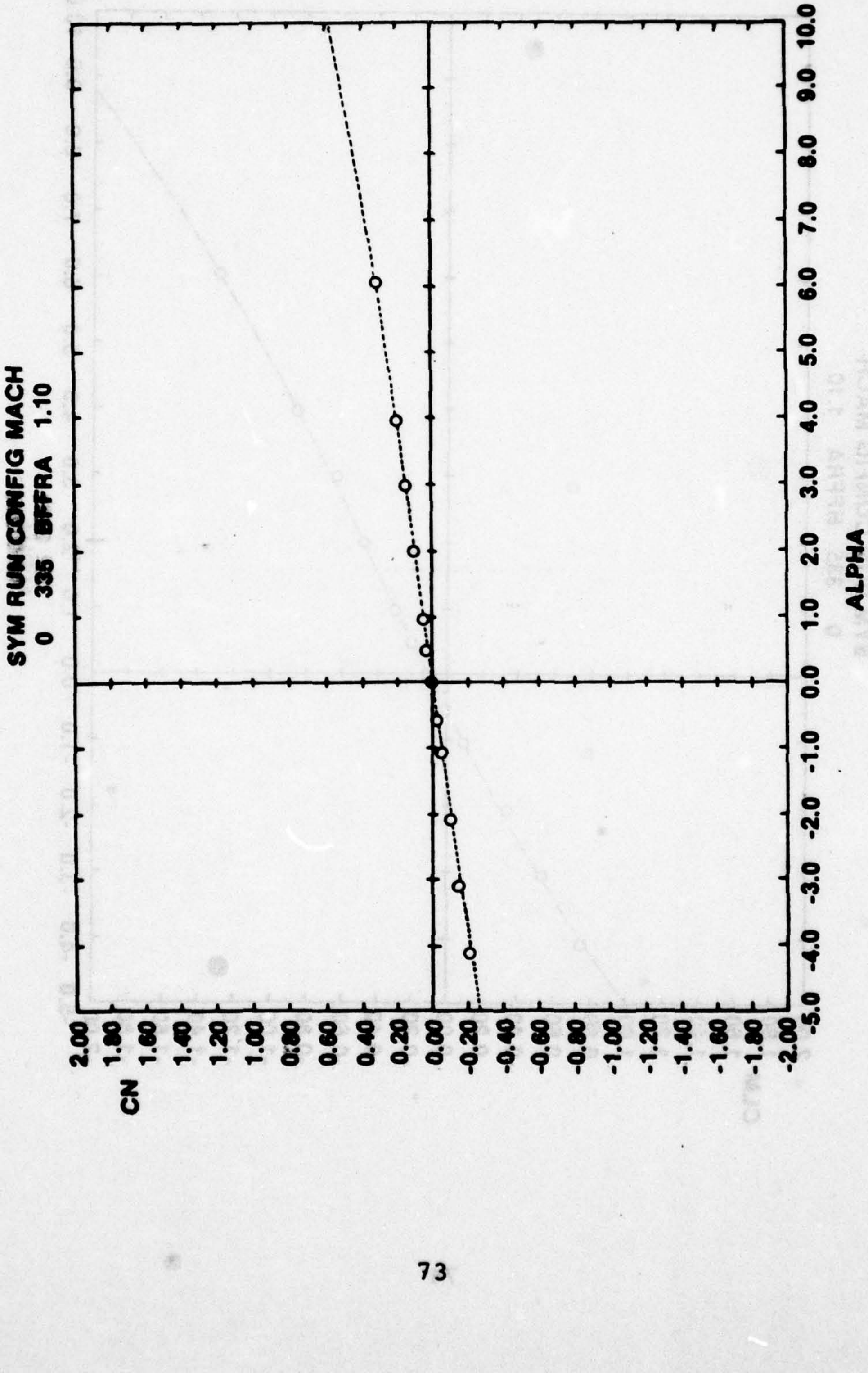

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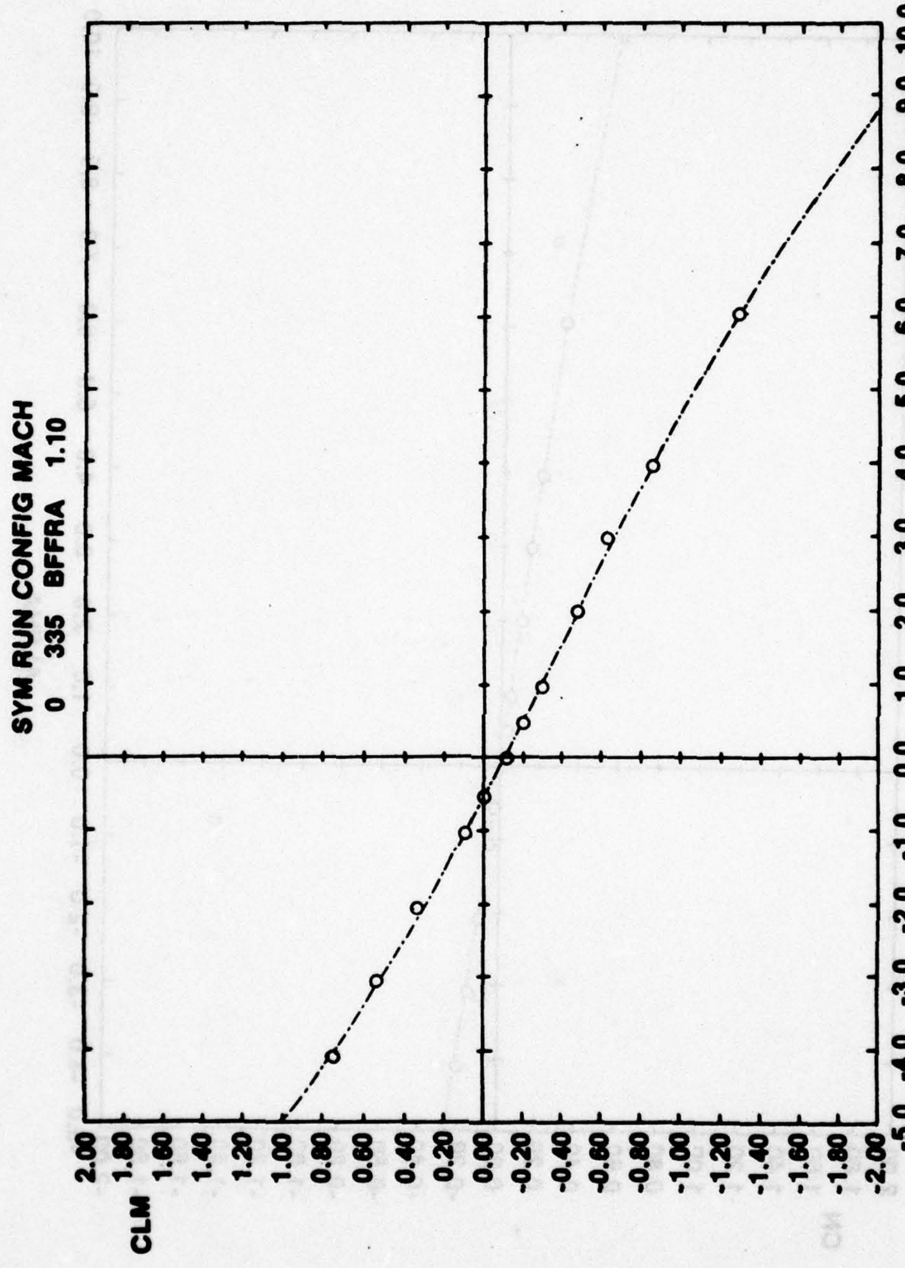
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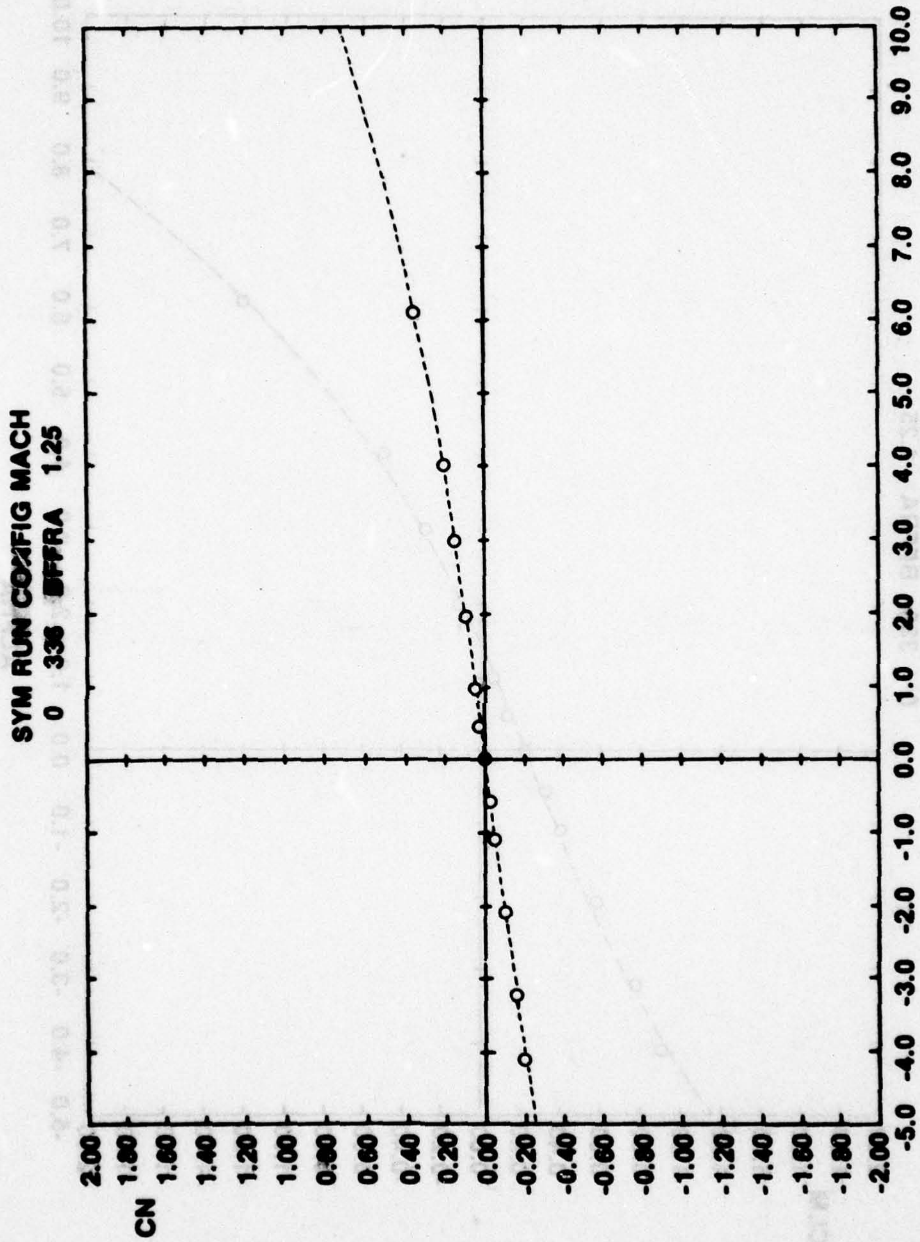
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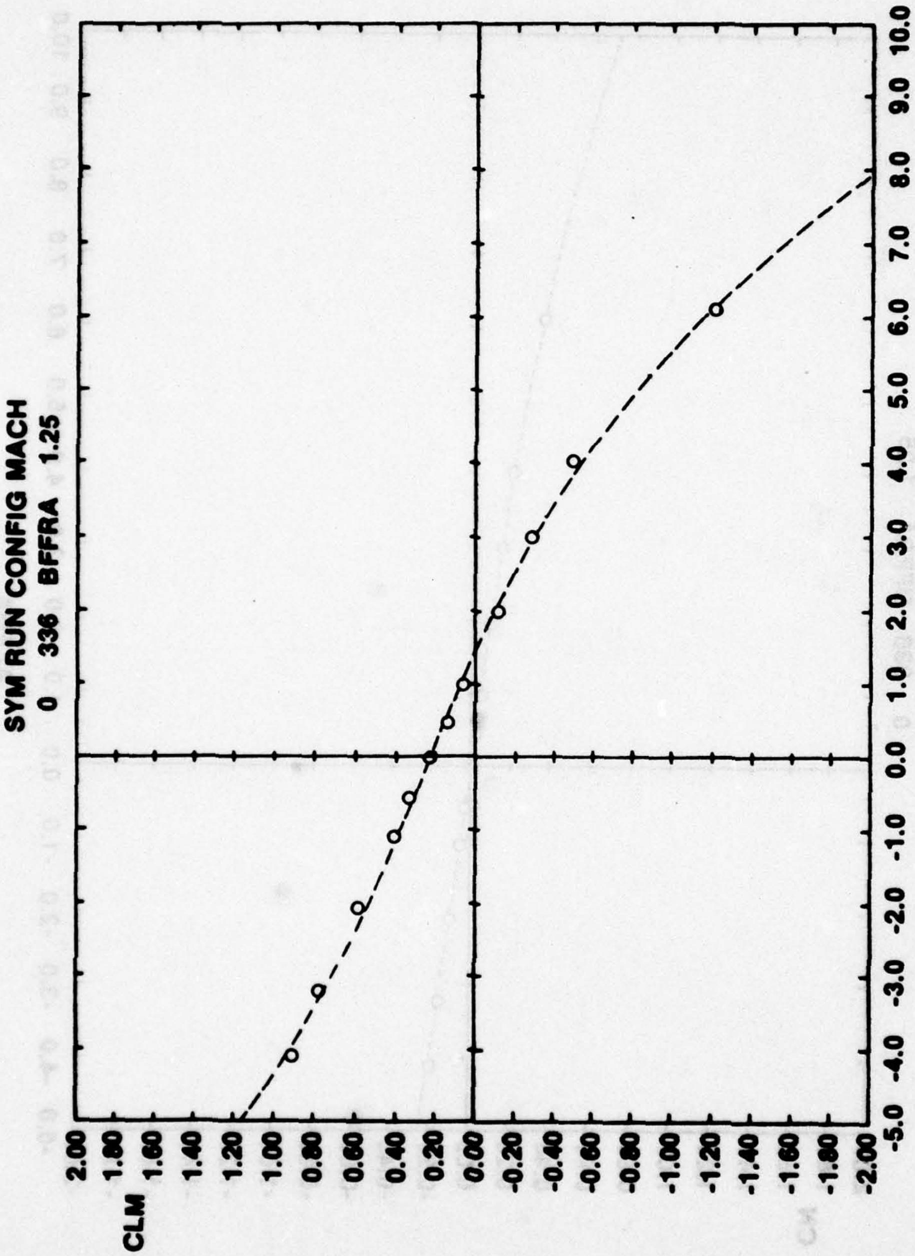
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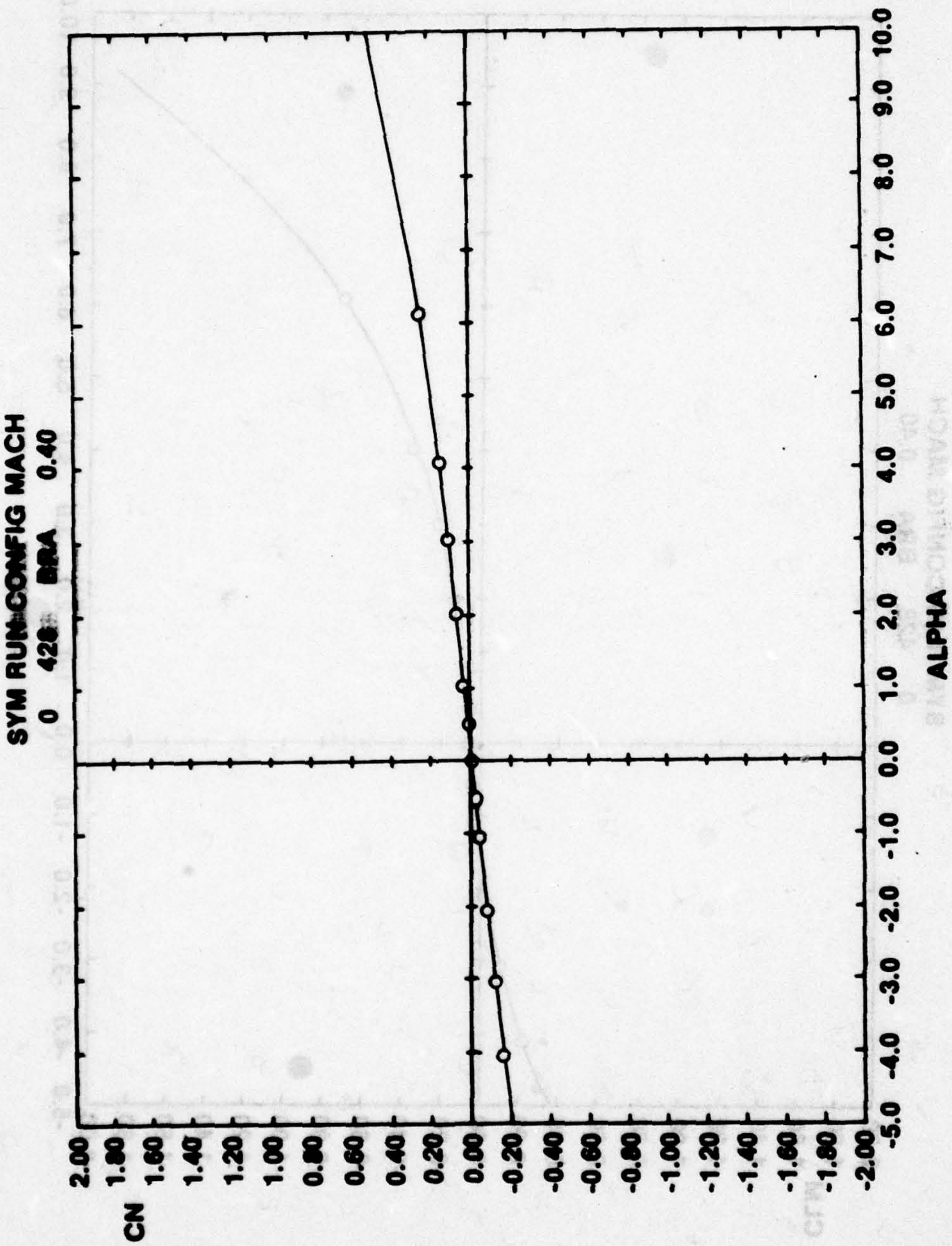
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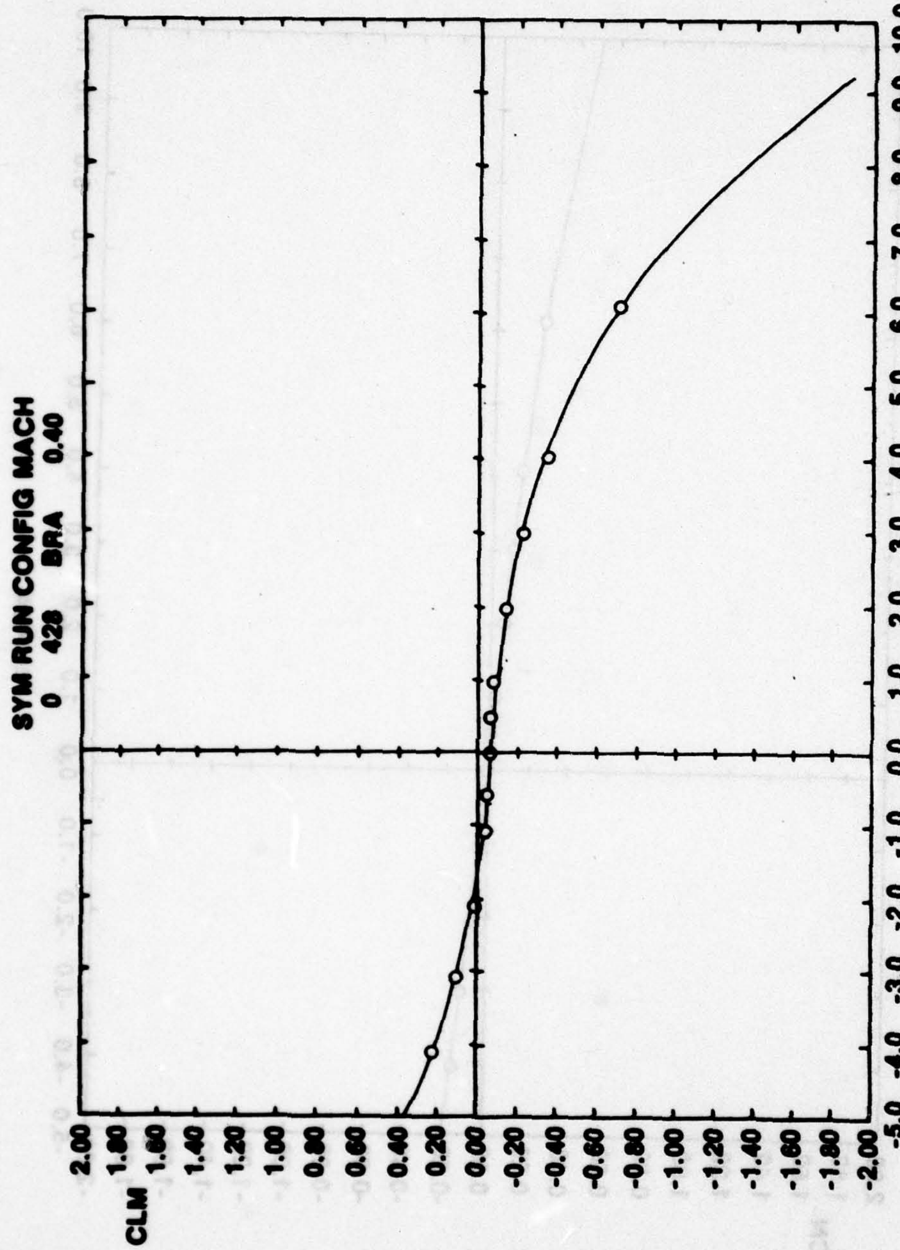
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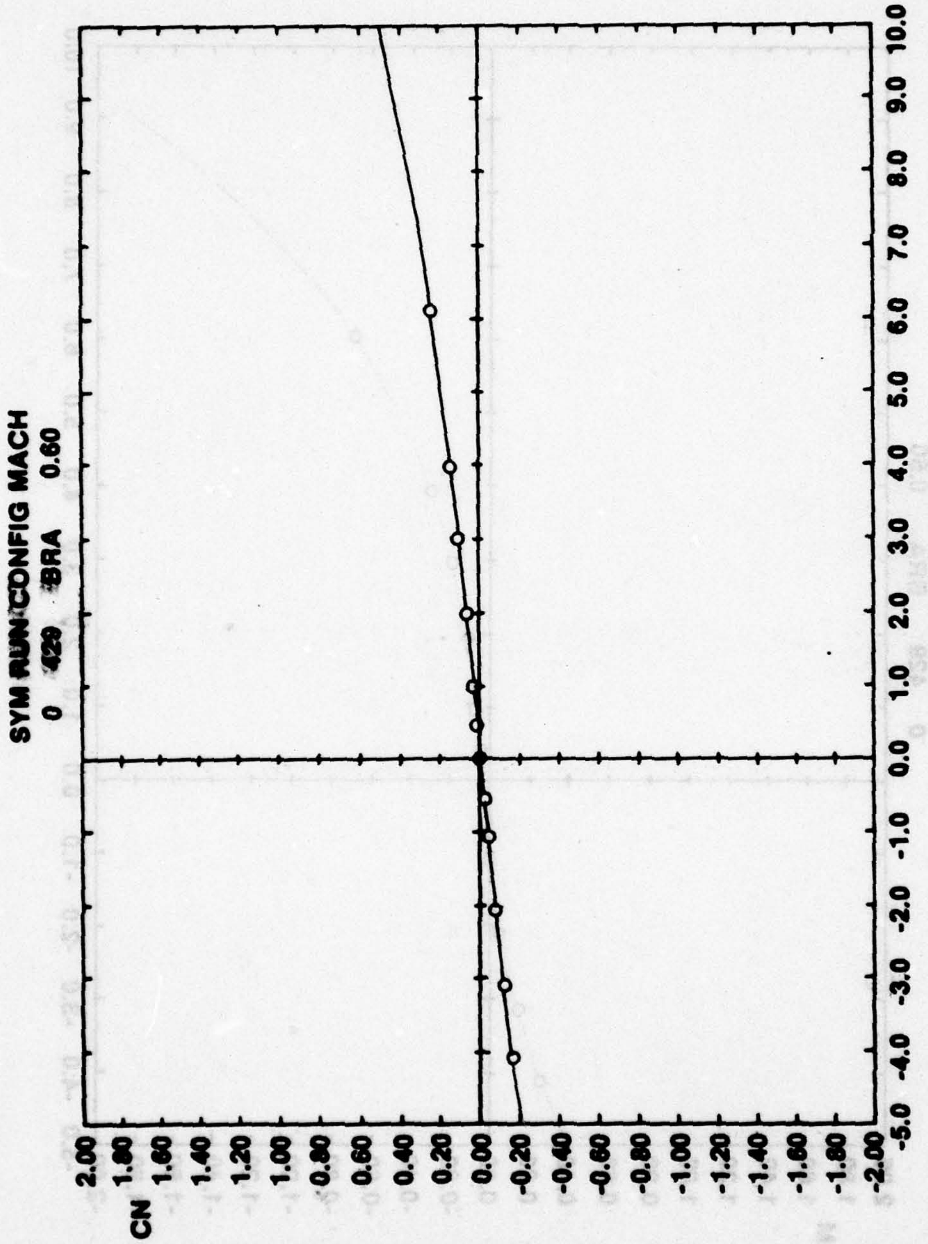
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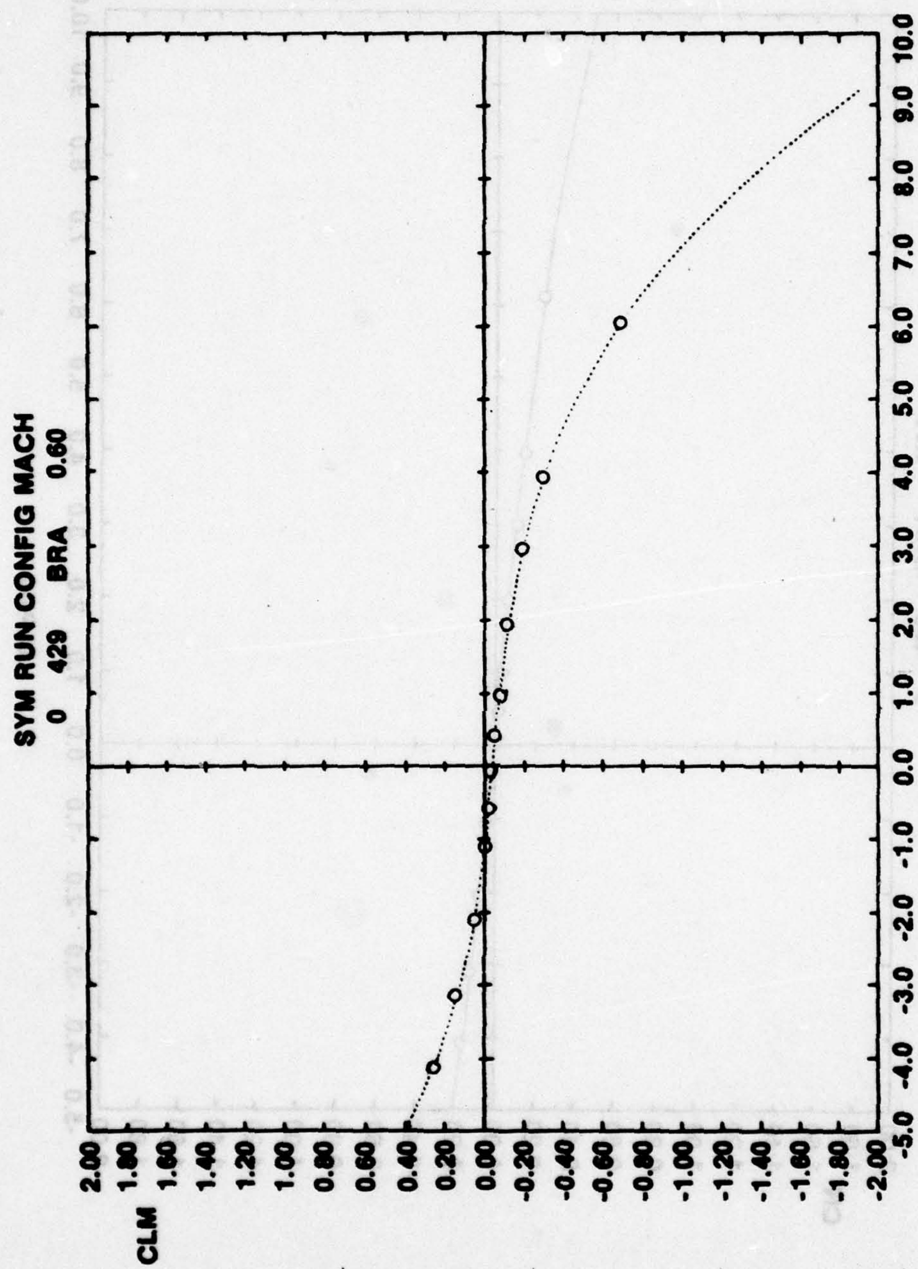
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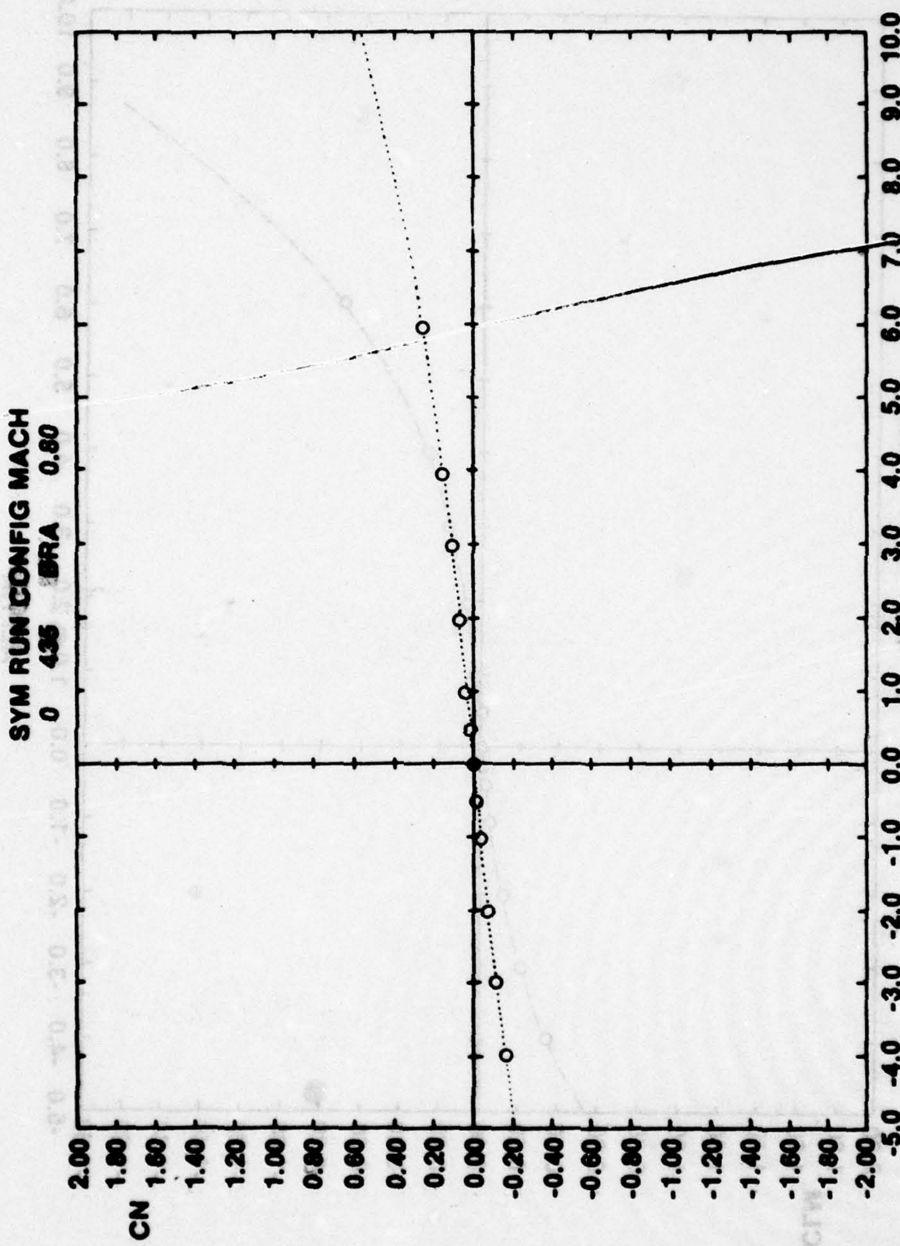
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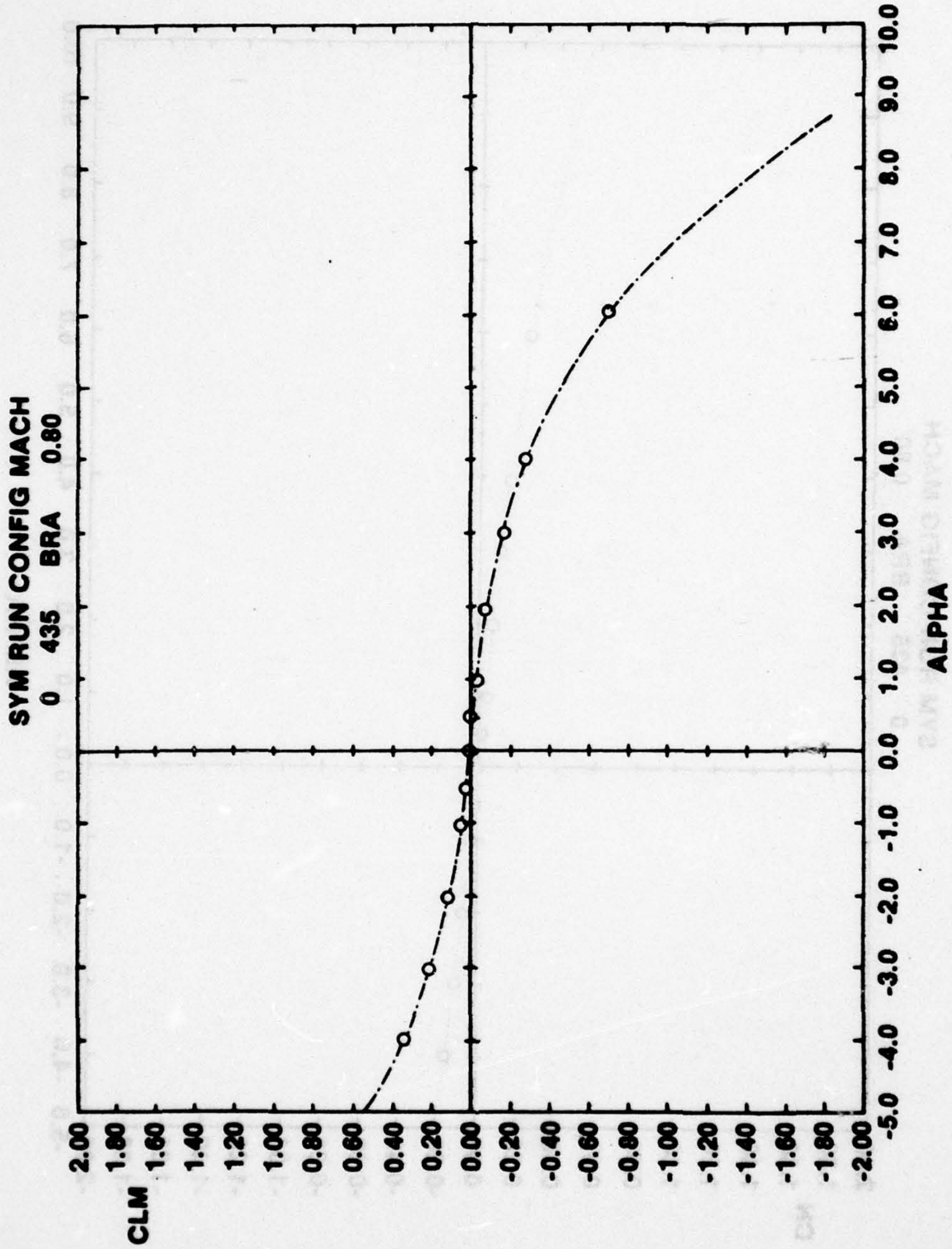
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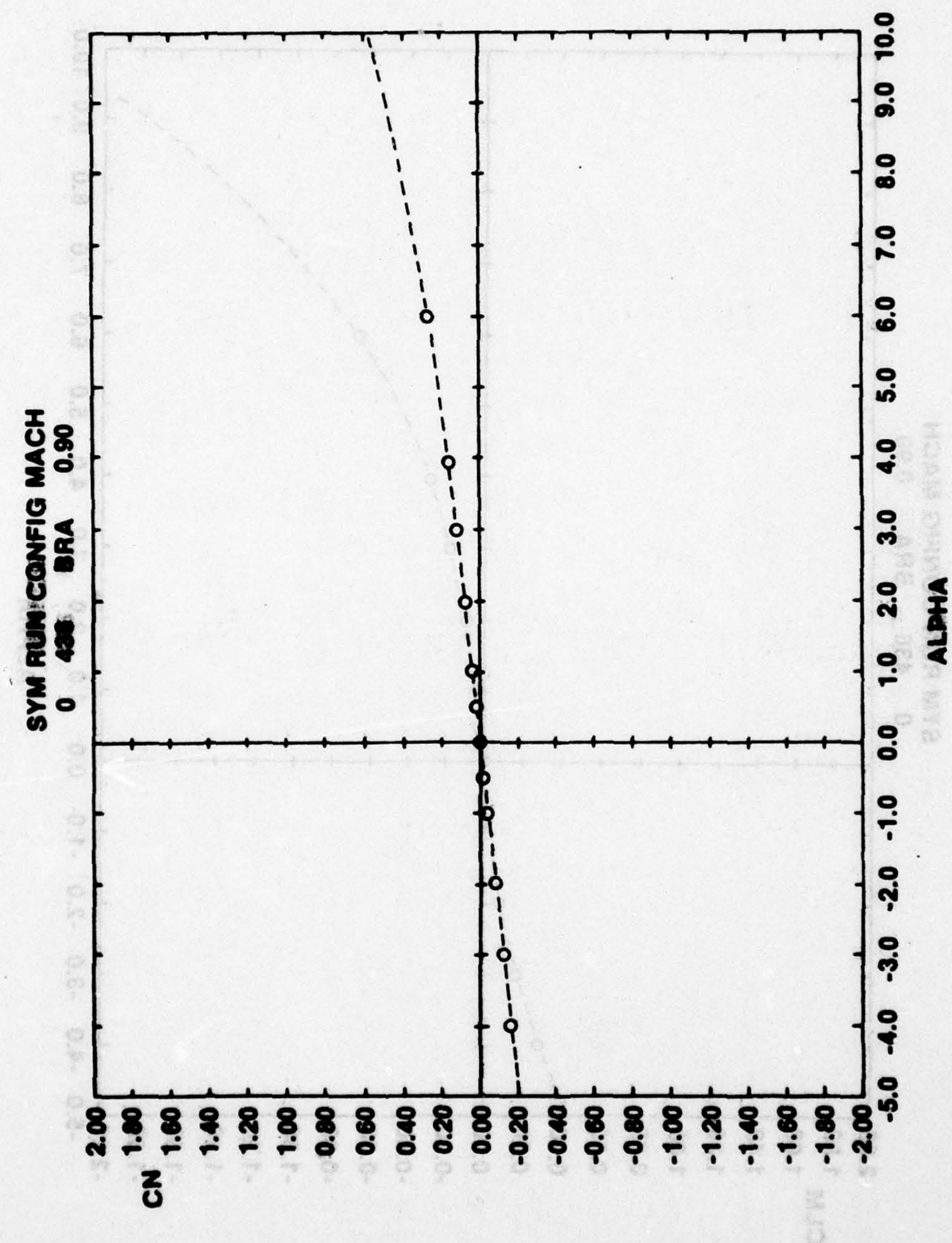
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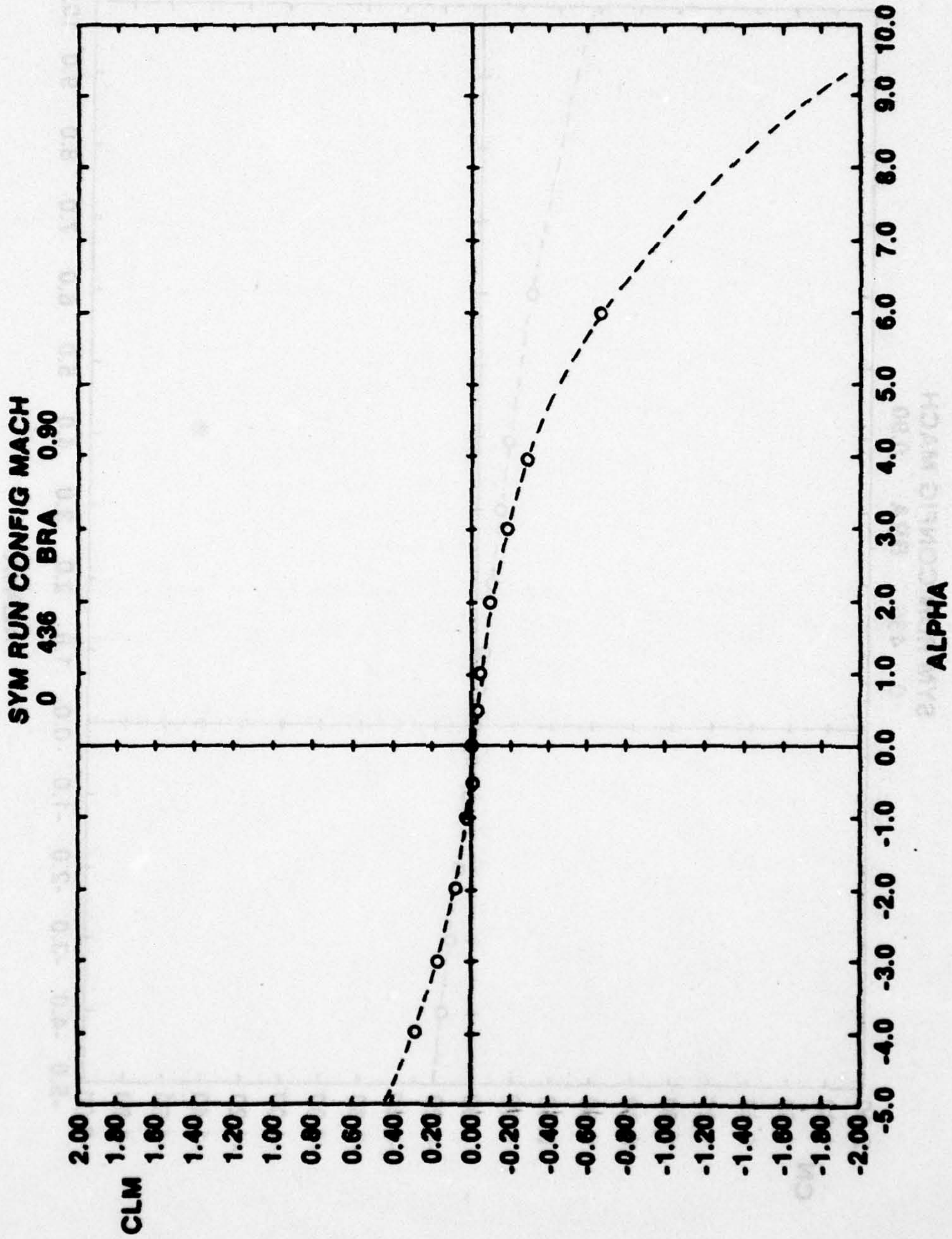
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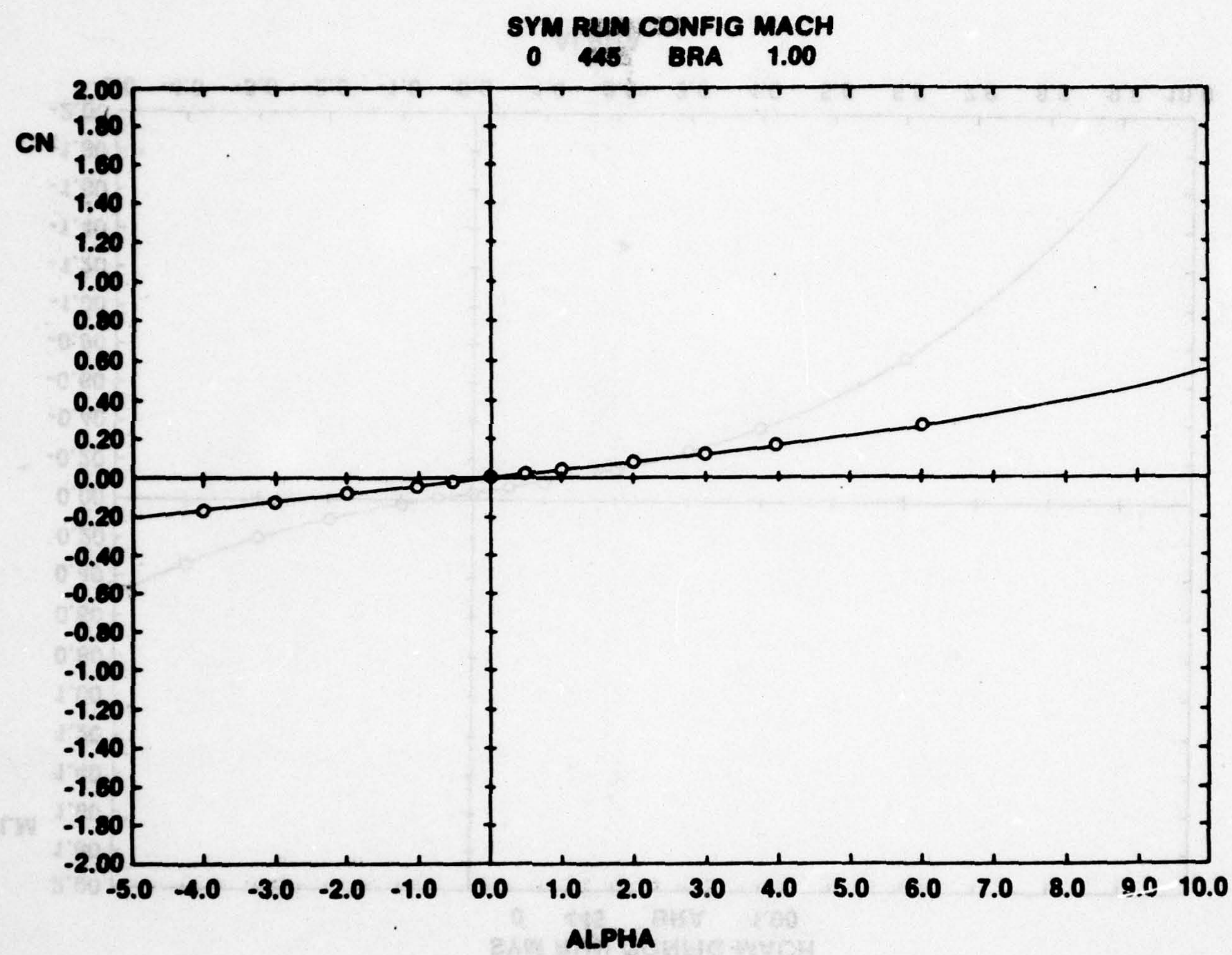
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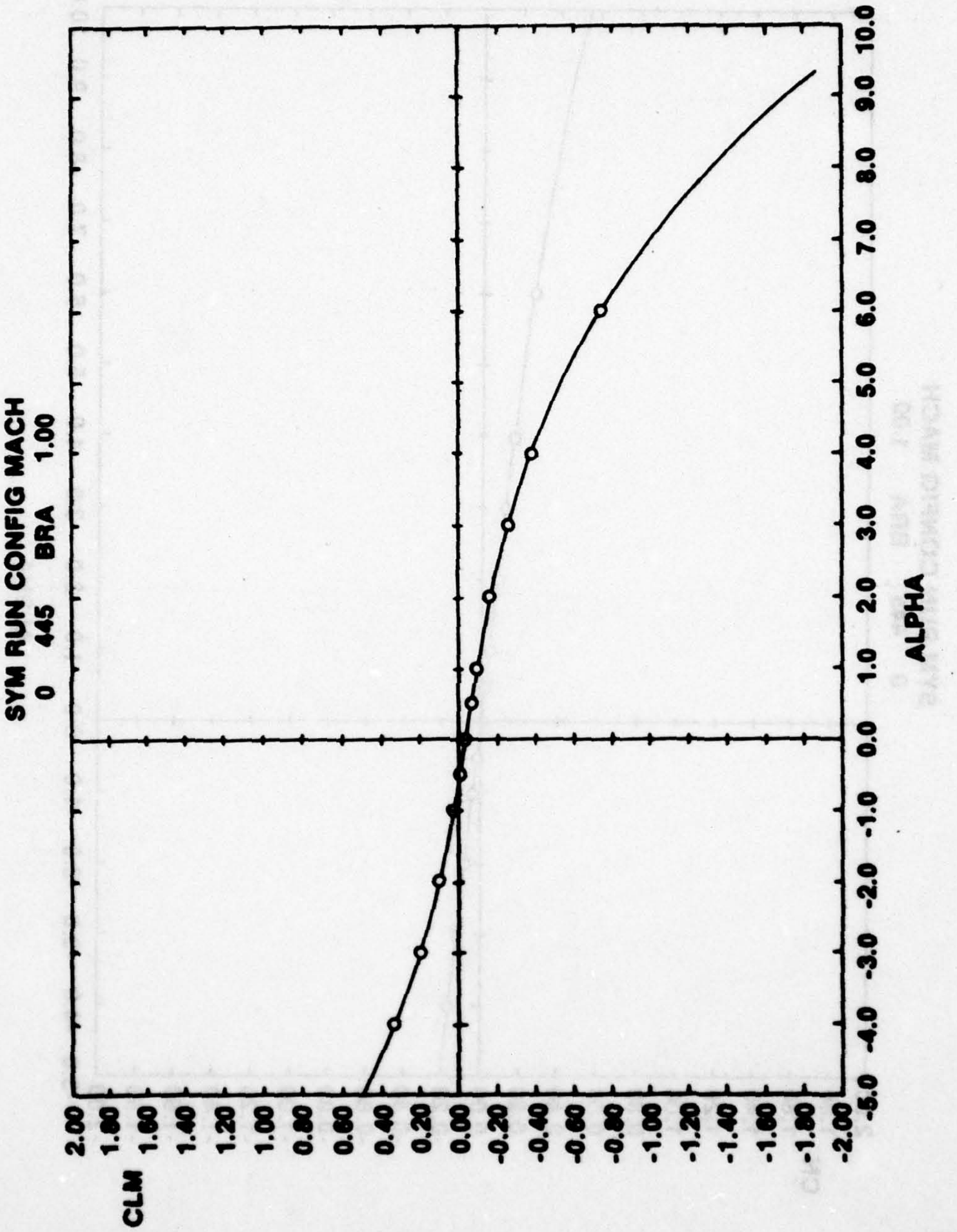
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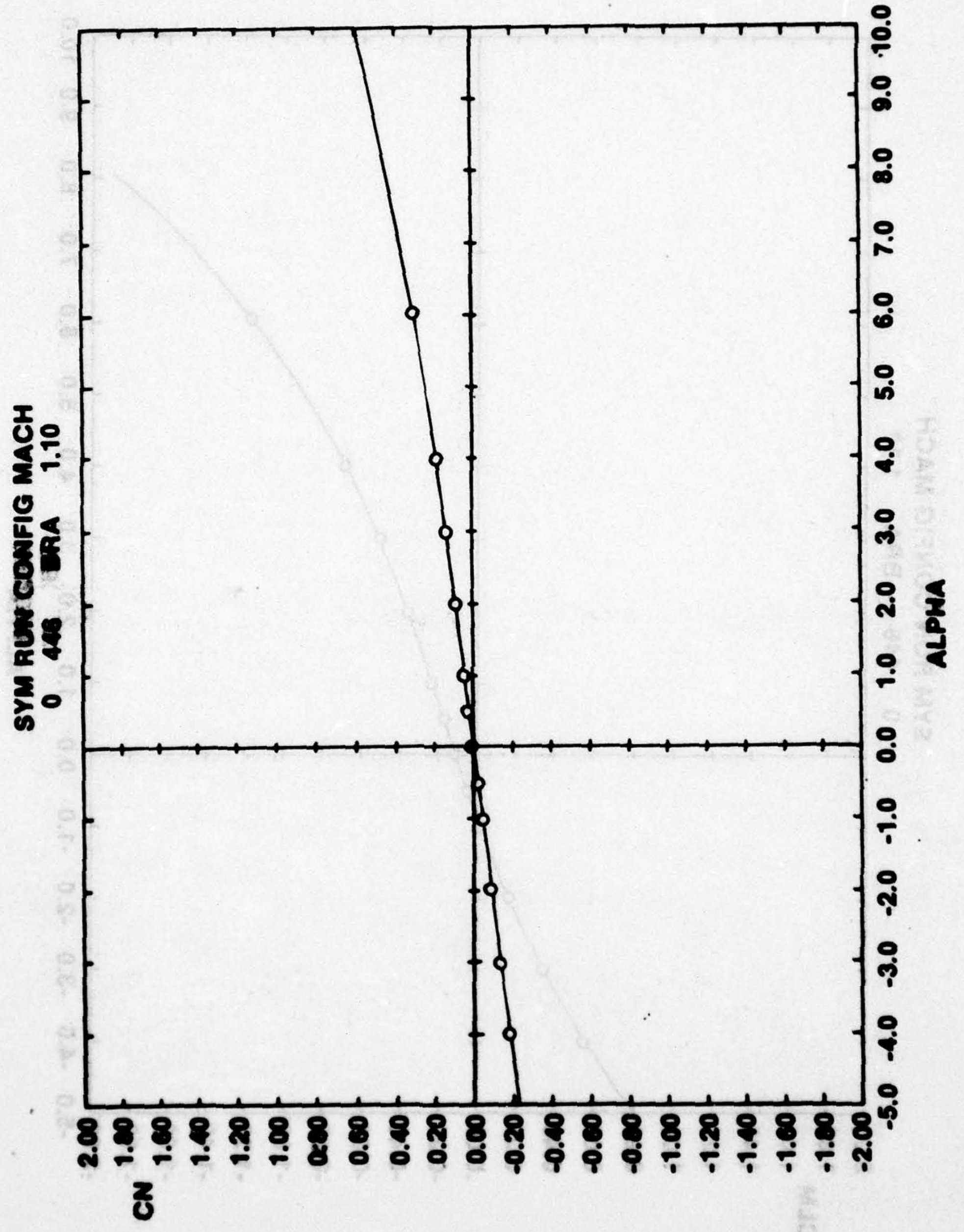
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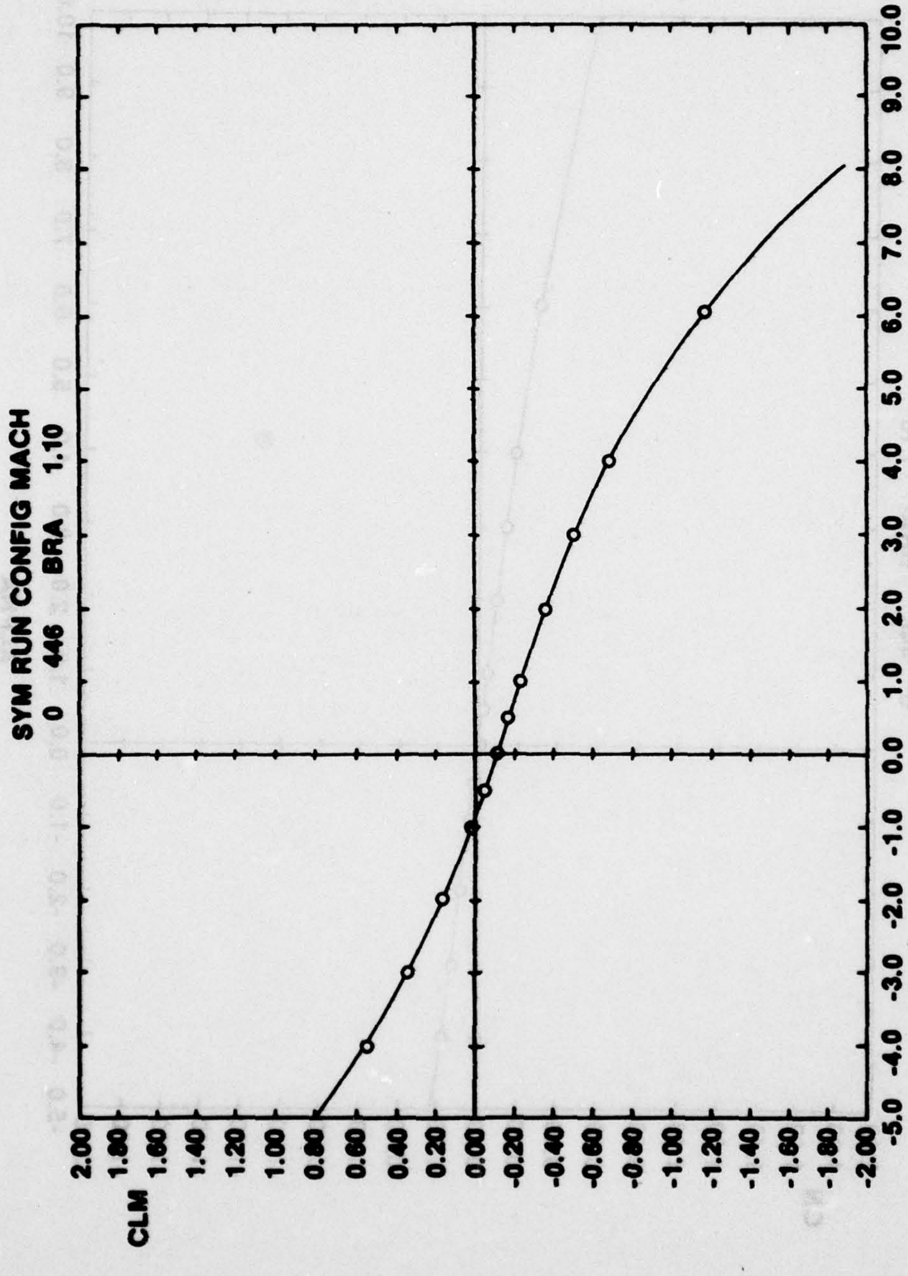
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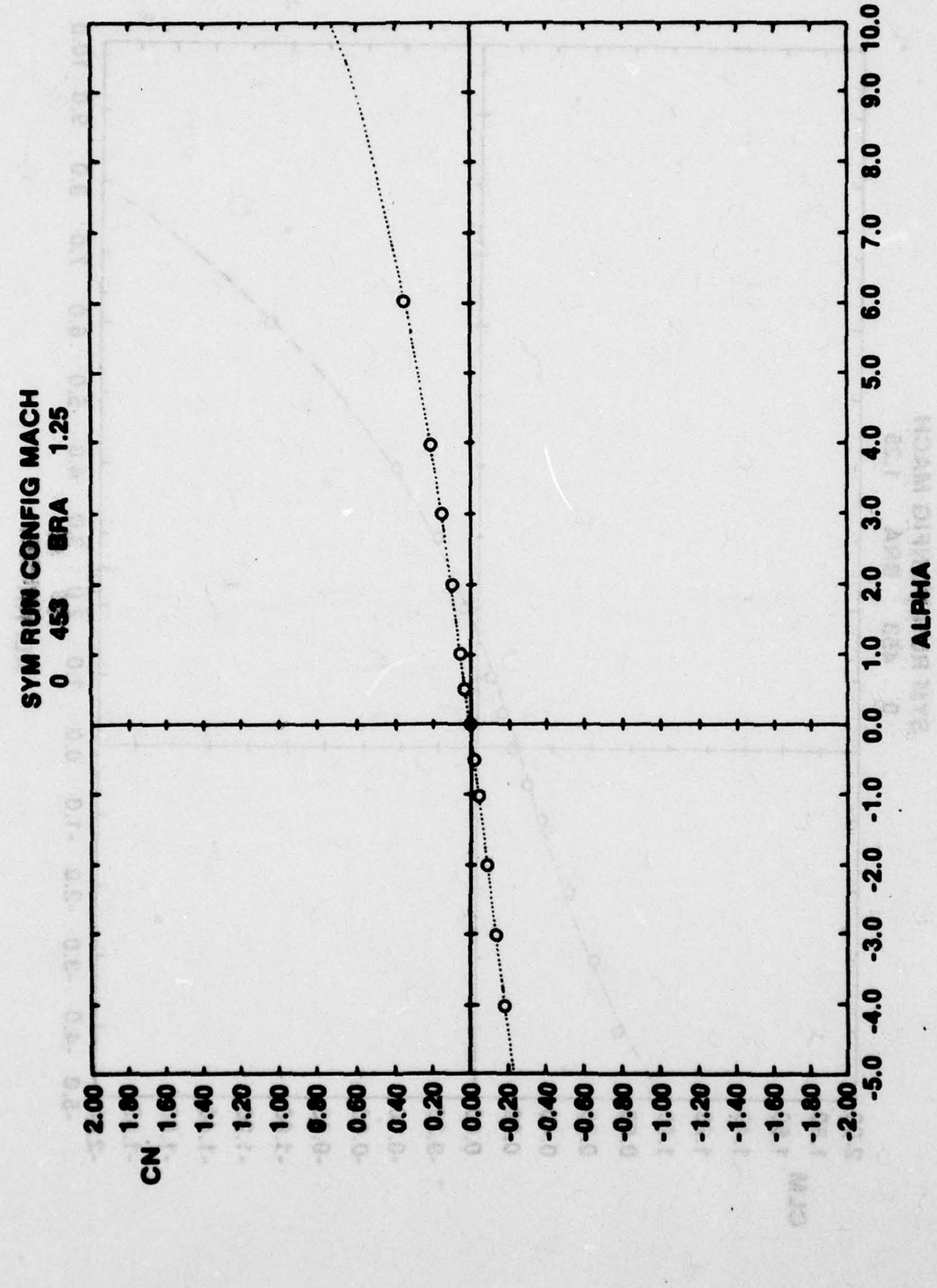
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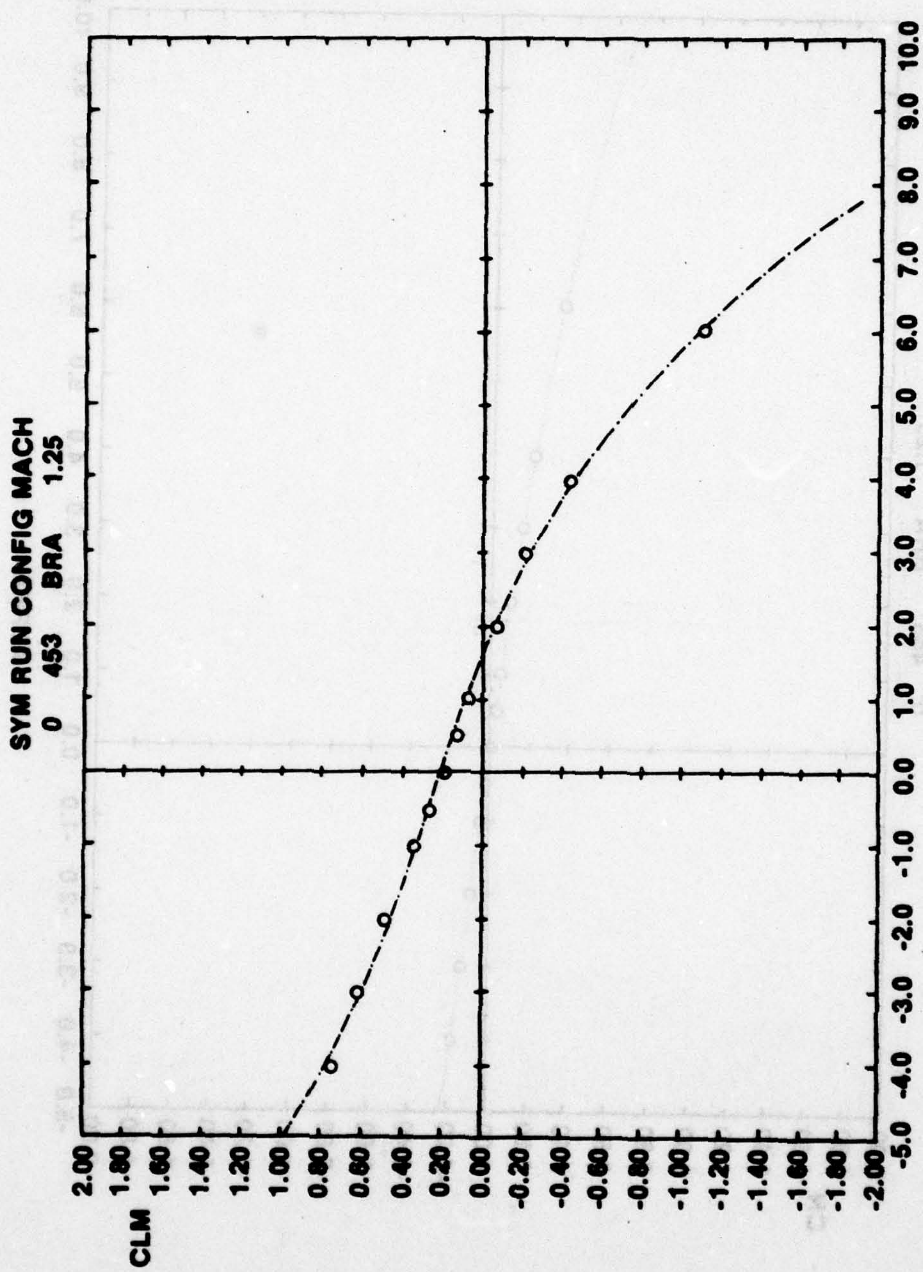
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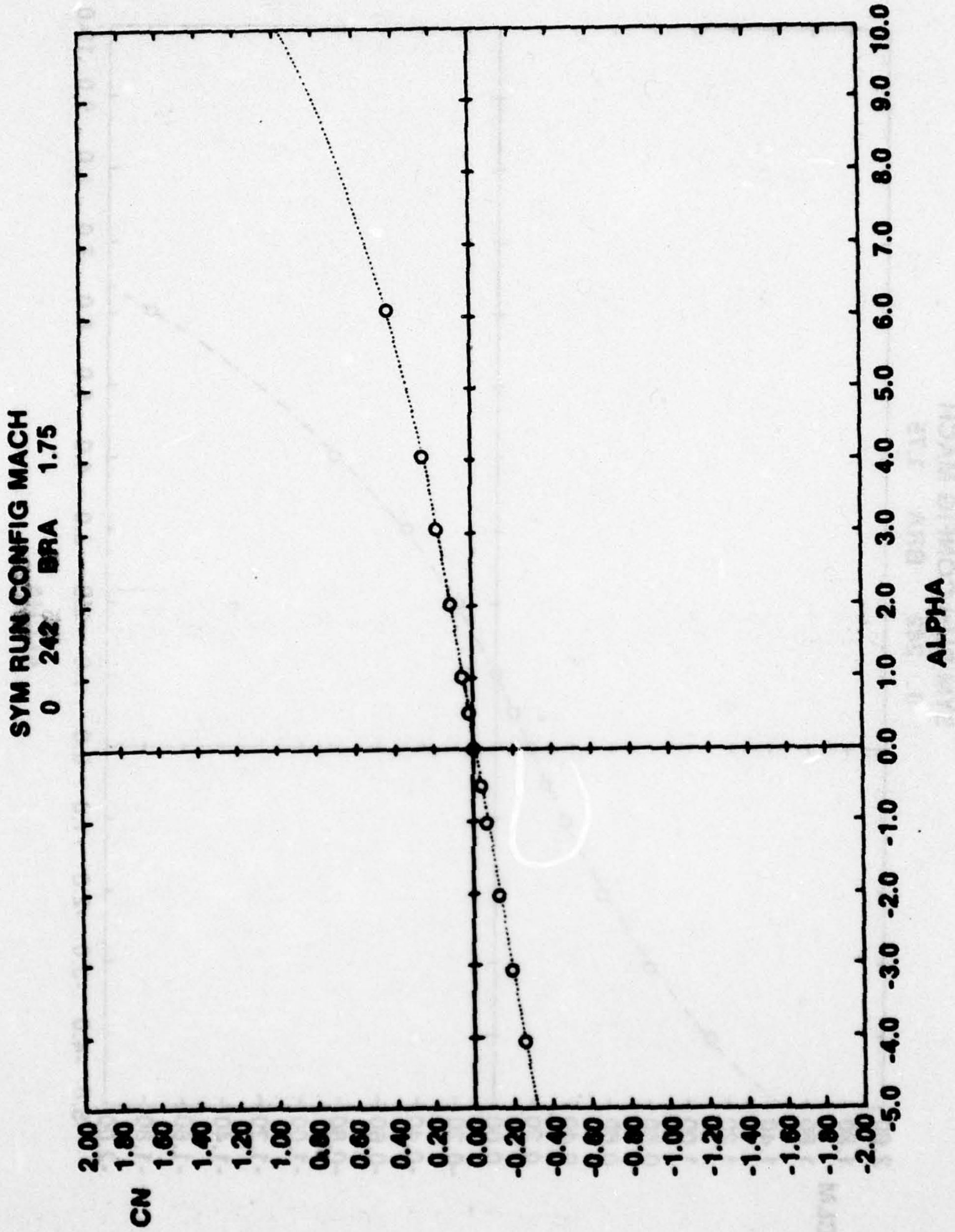
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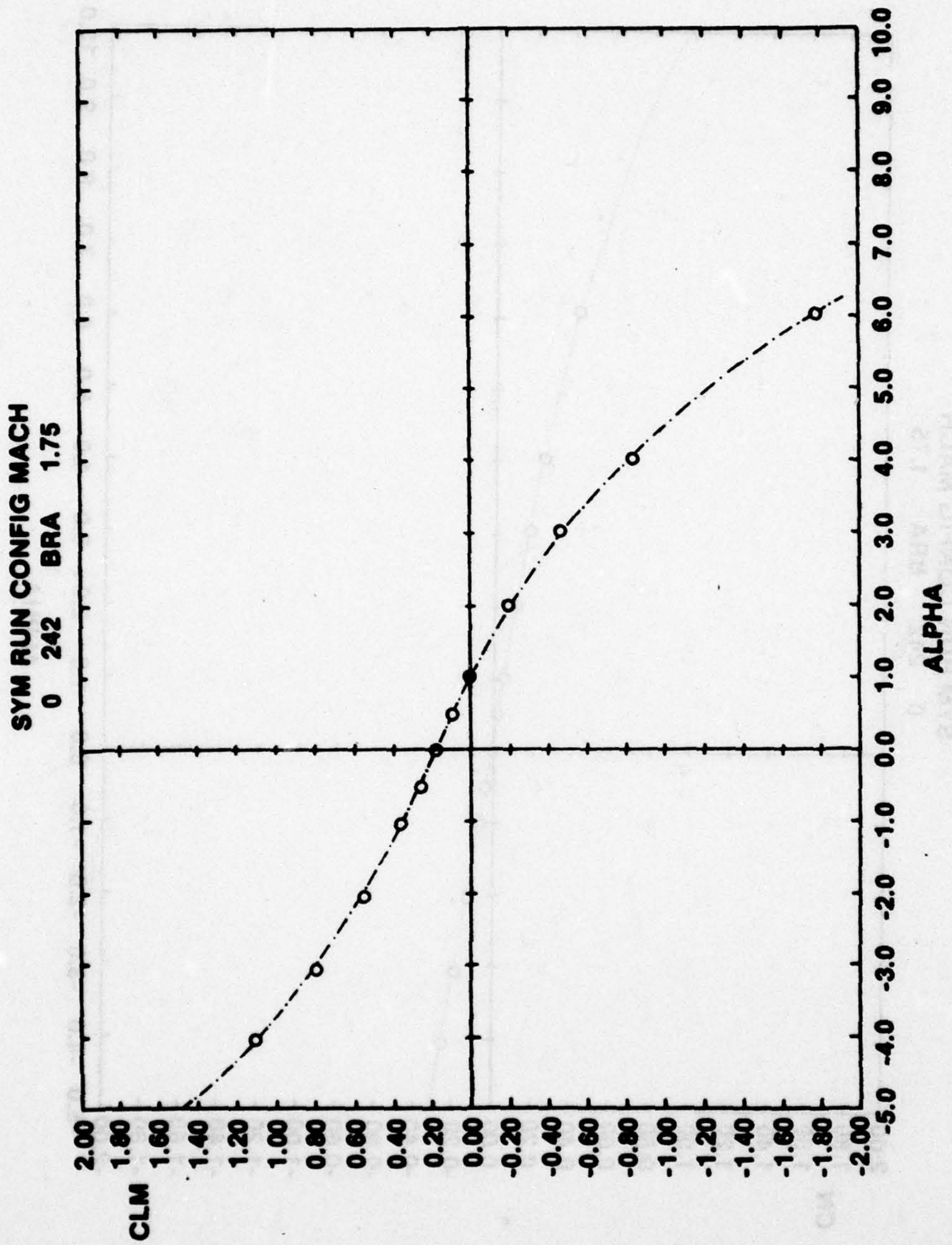
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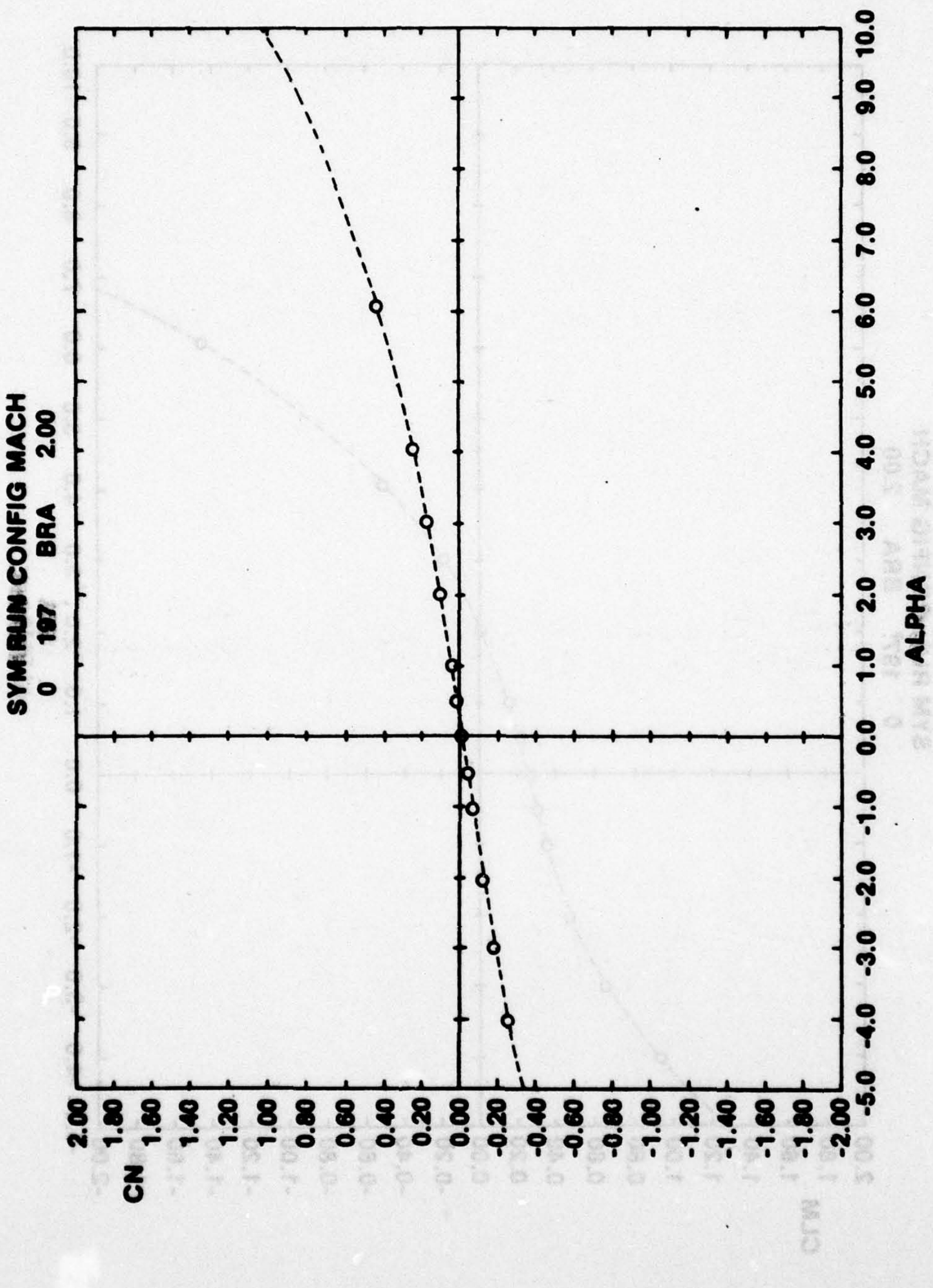

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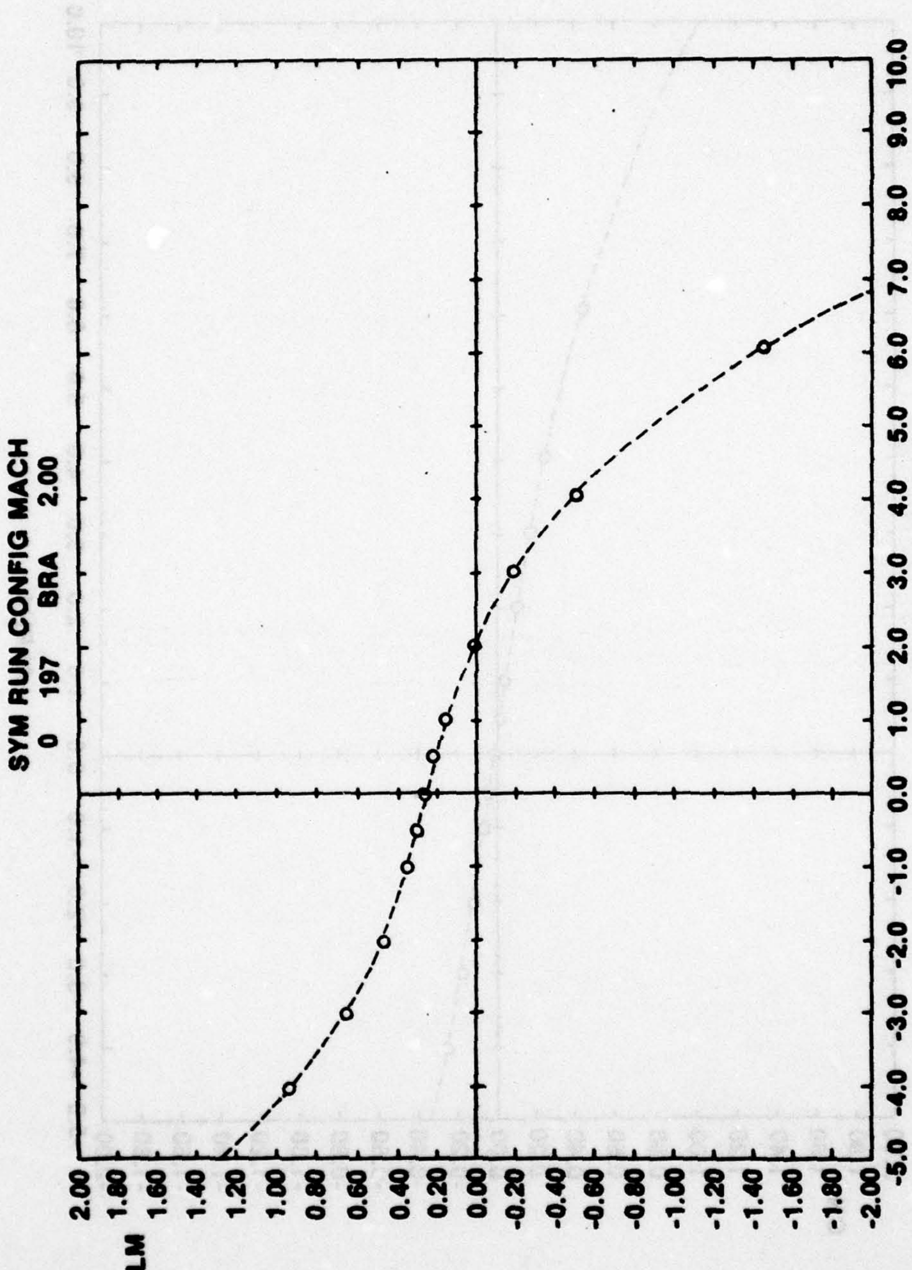
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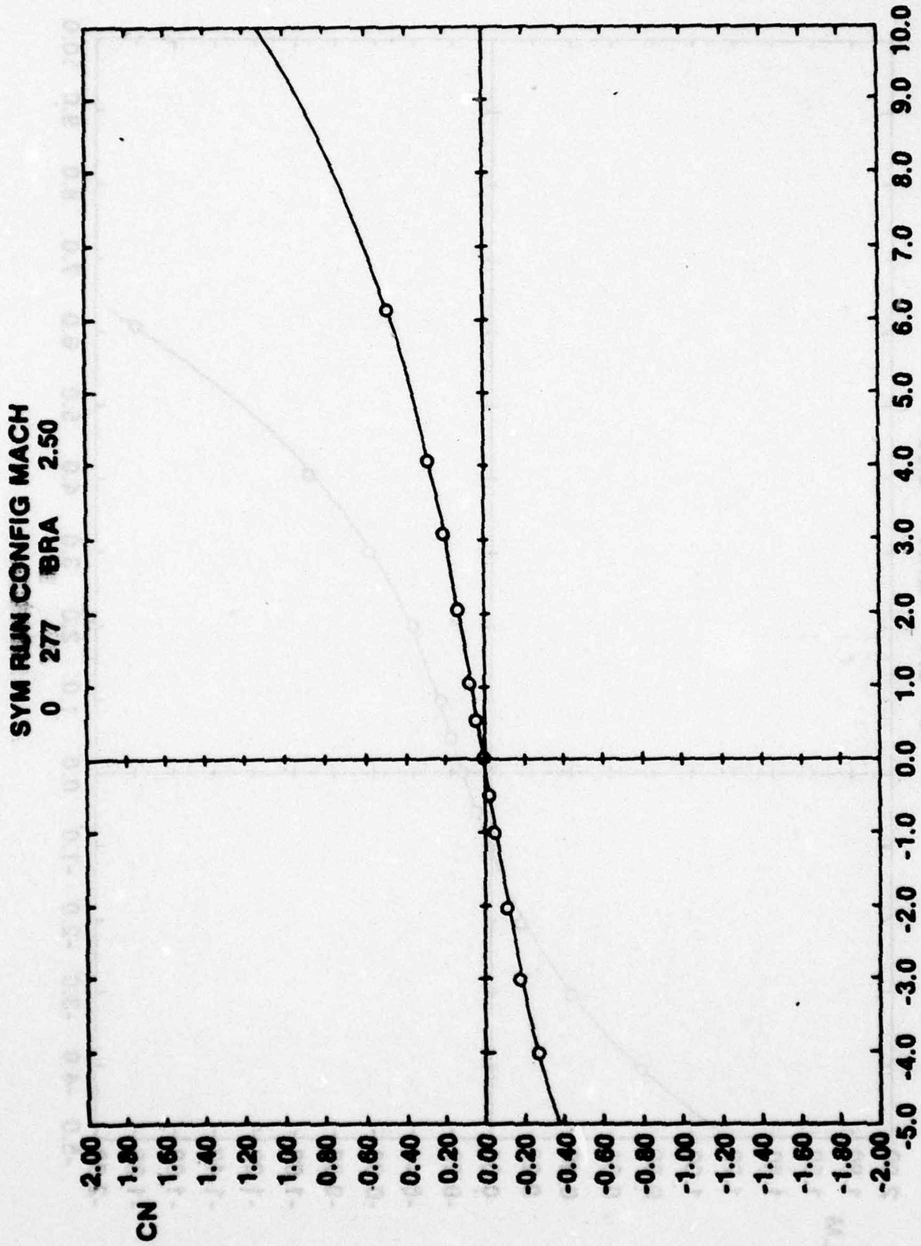

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AD-A066 733 ARMY MISSILE RESEARCH AND DEVELOPMENT COMMAND REDSTO--ETC F/G 19/7
THE AERODYNAMIC CHARACTERISTICS OF THE FREE FLIGHT DEMONSTRATIO--ETC(U)
JAN 79 J A HUMPHREY

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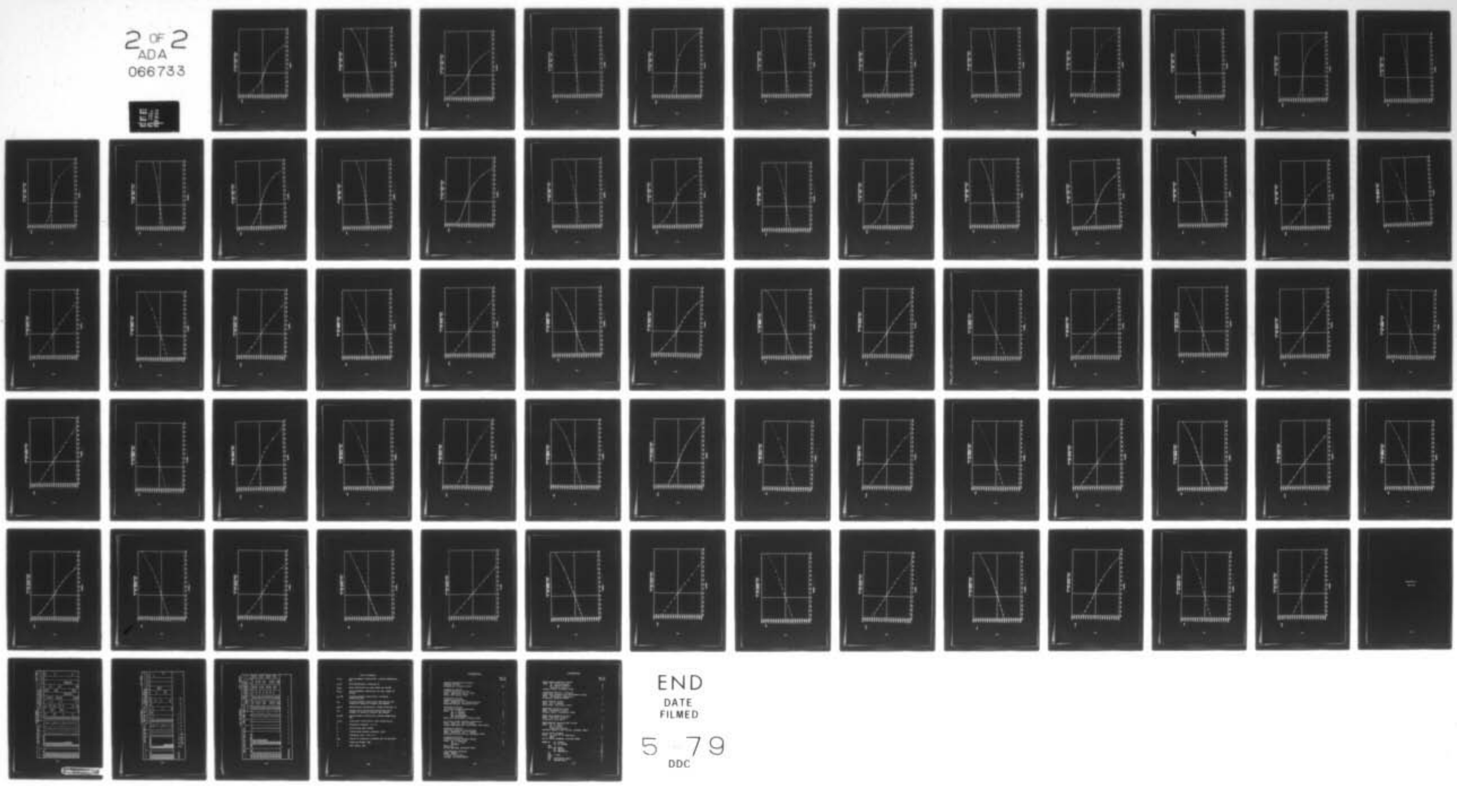

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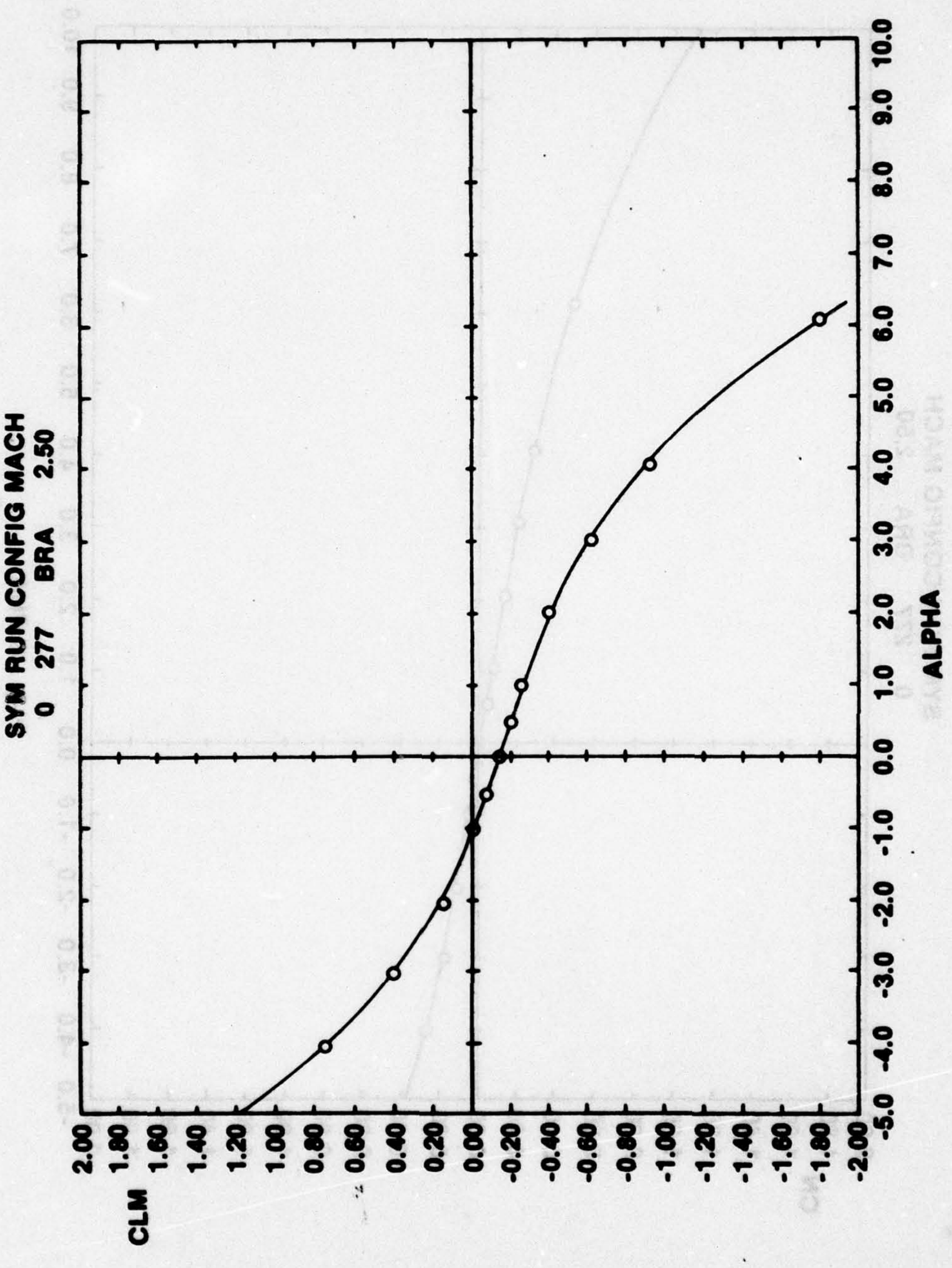
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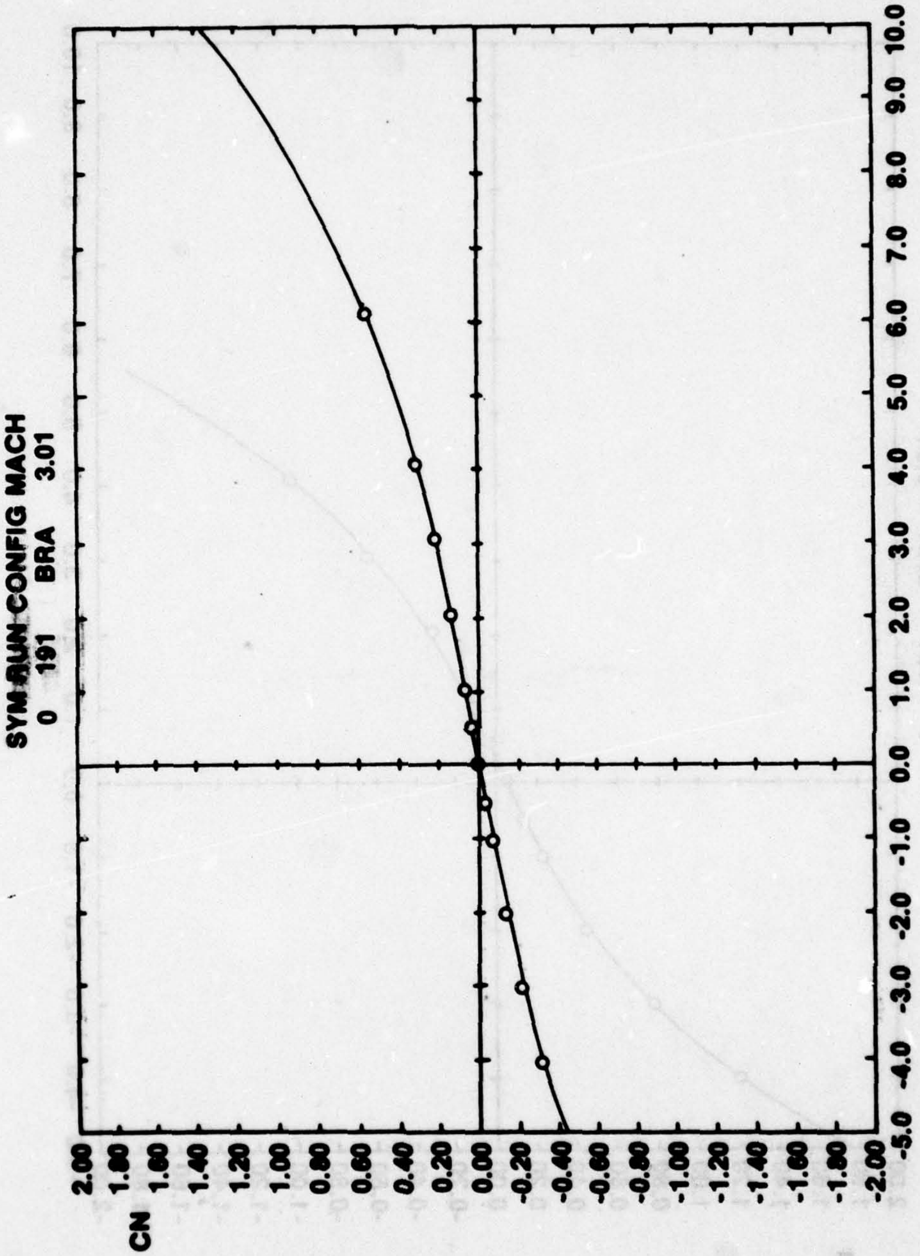
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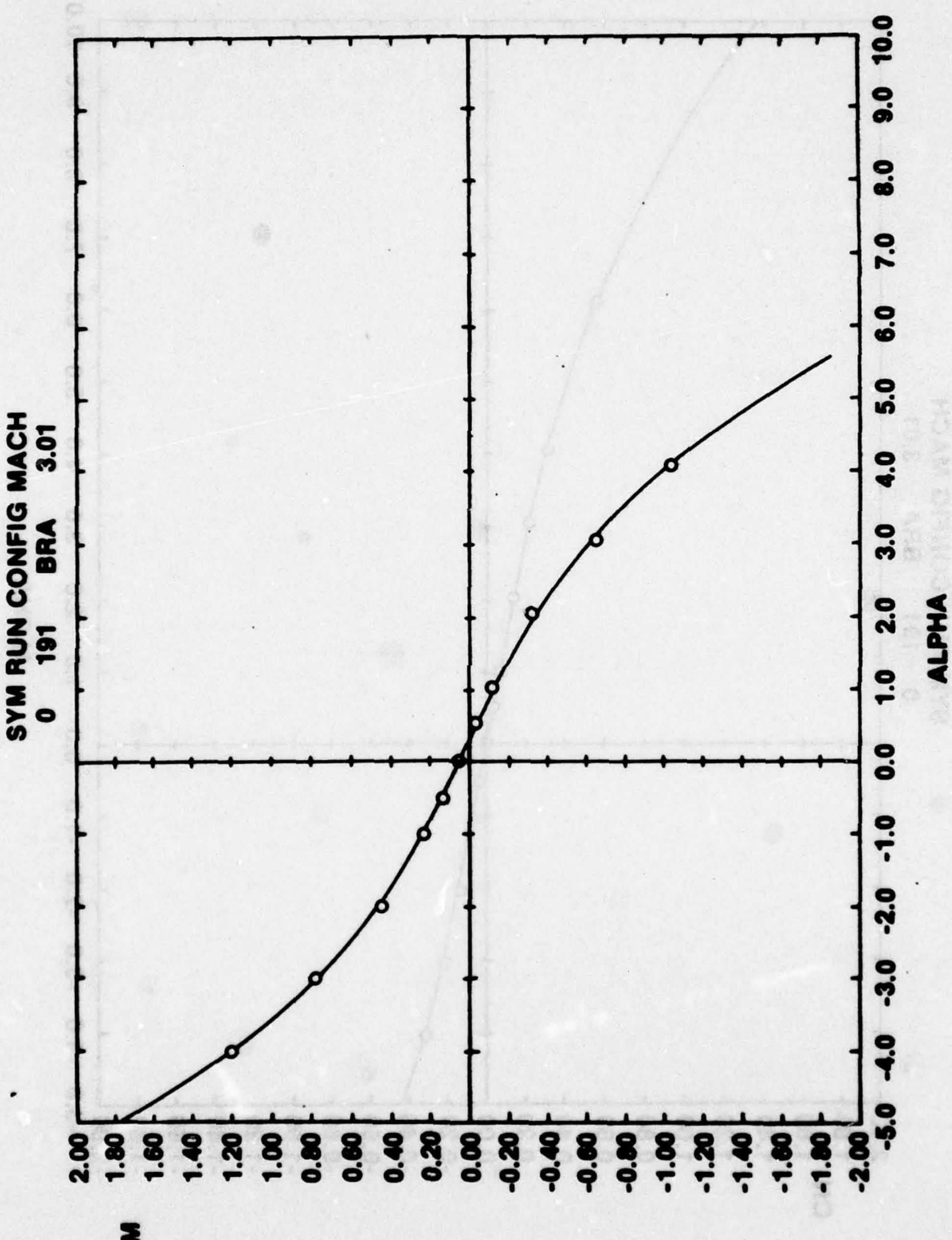
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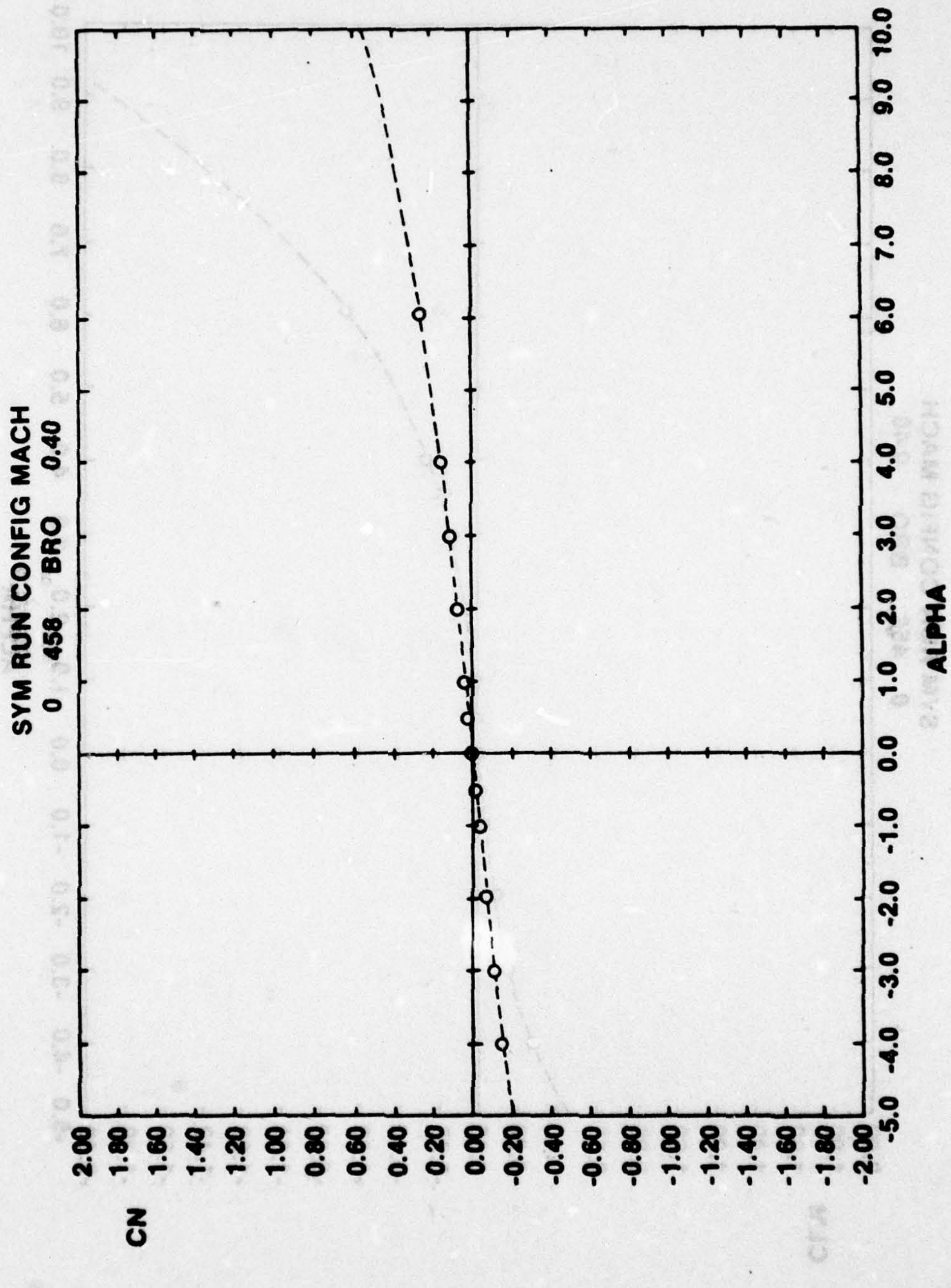
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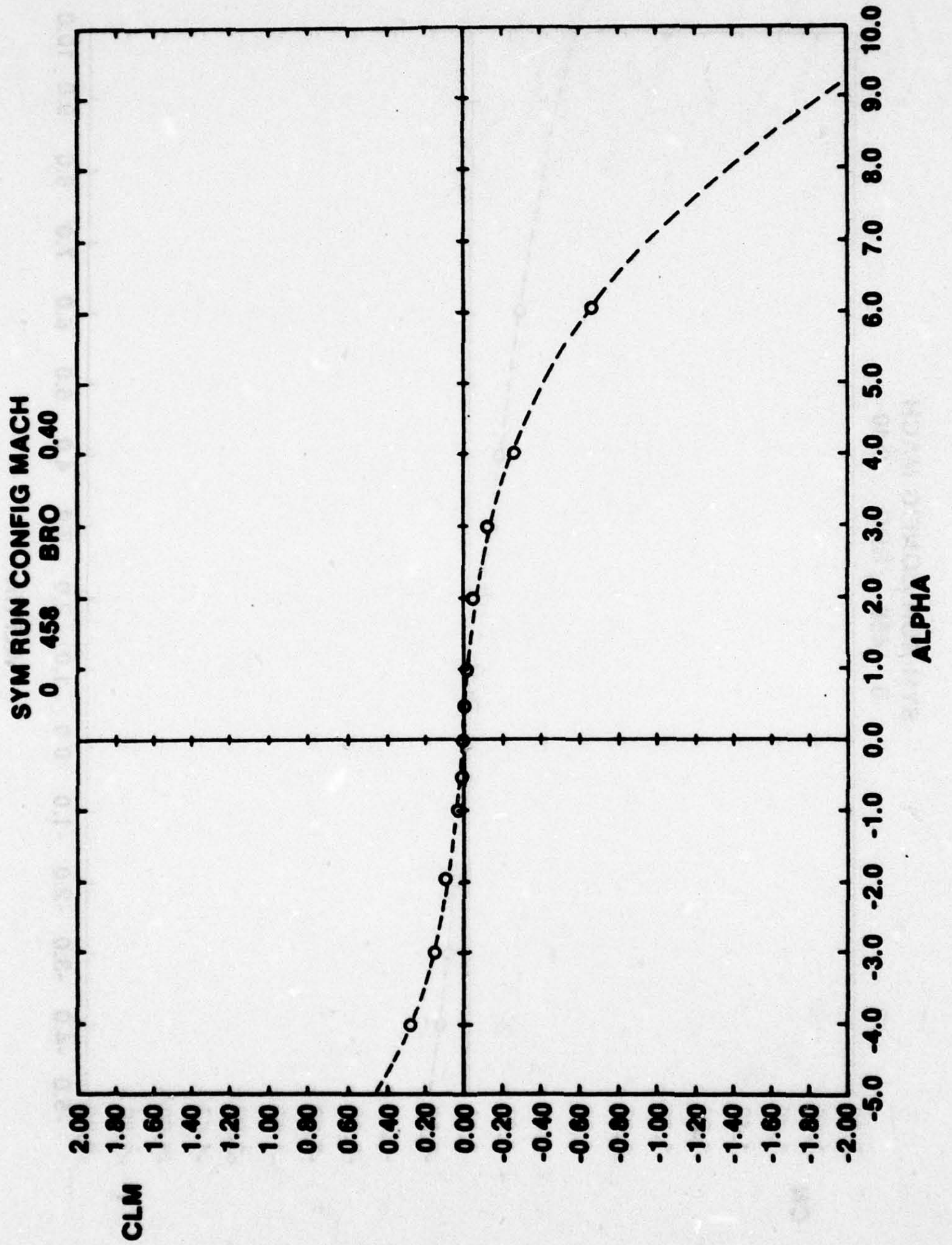
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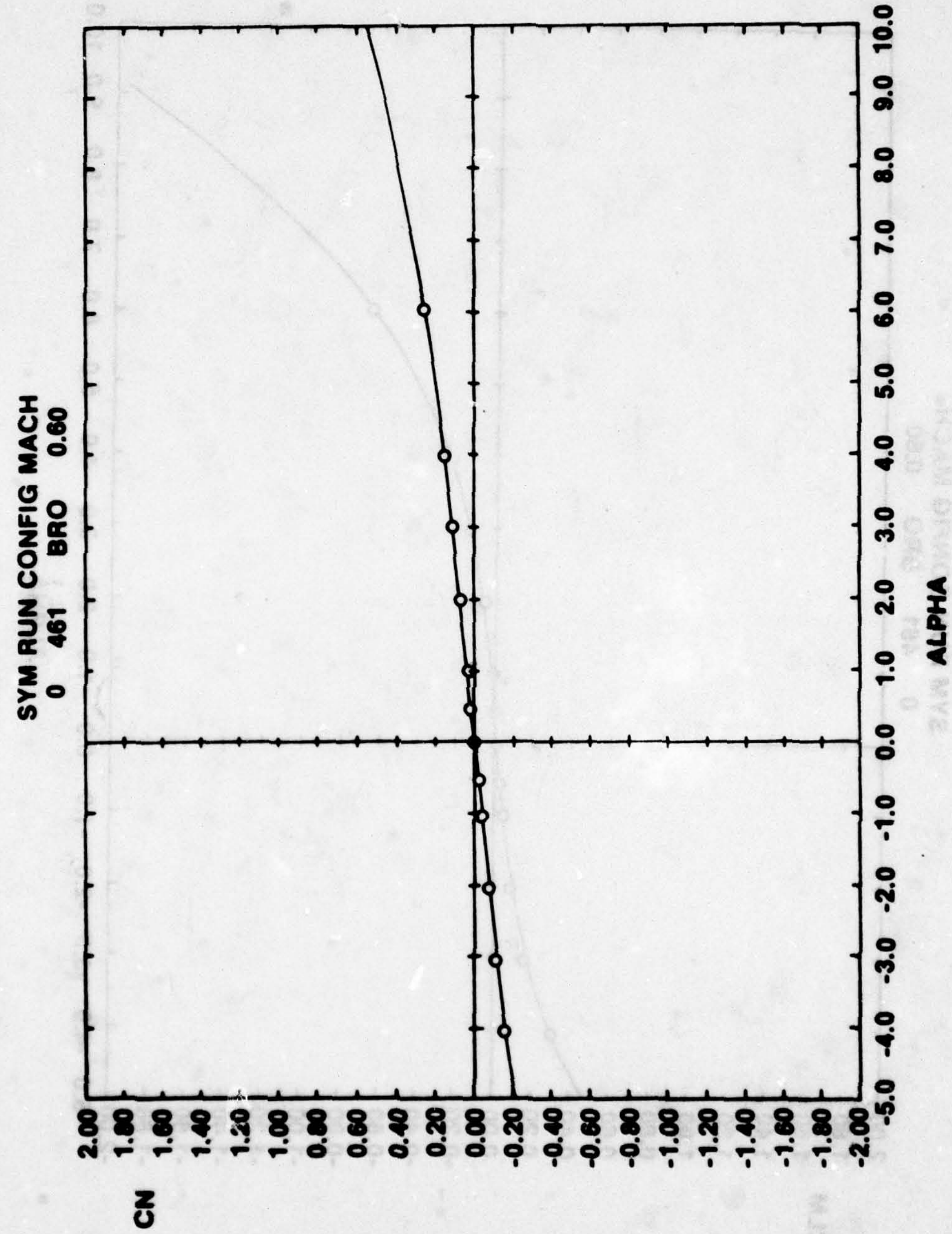

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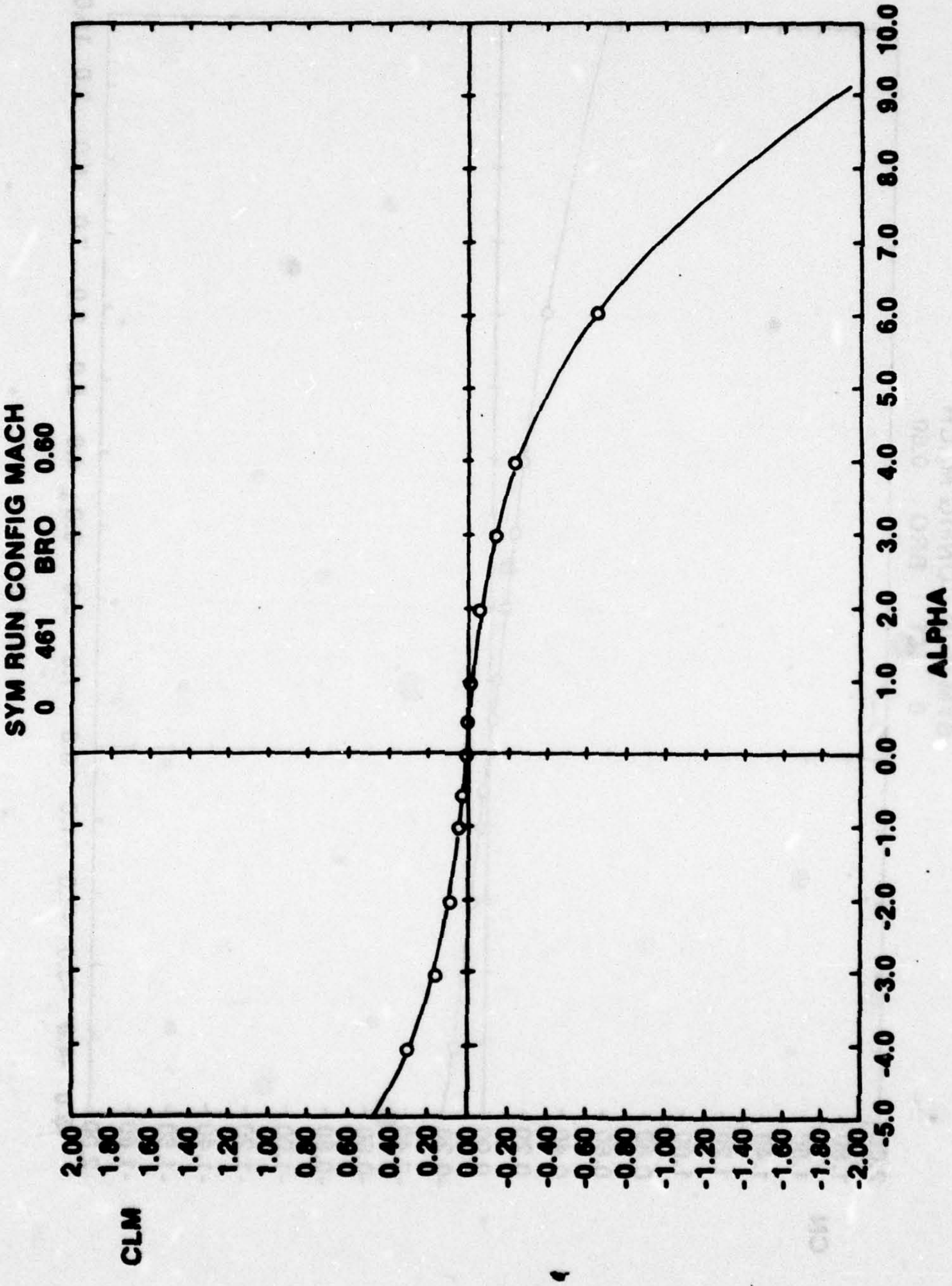

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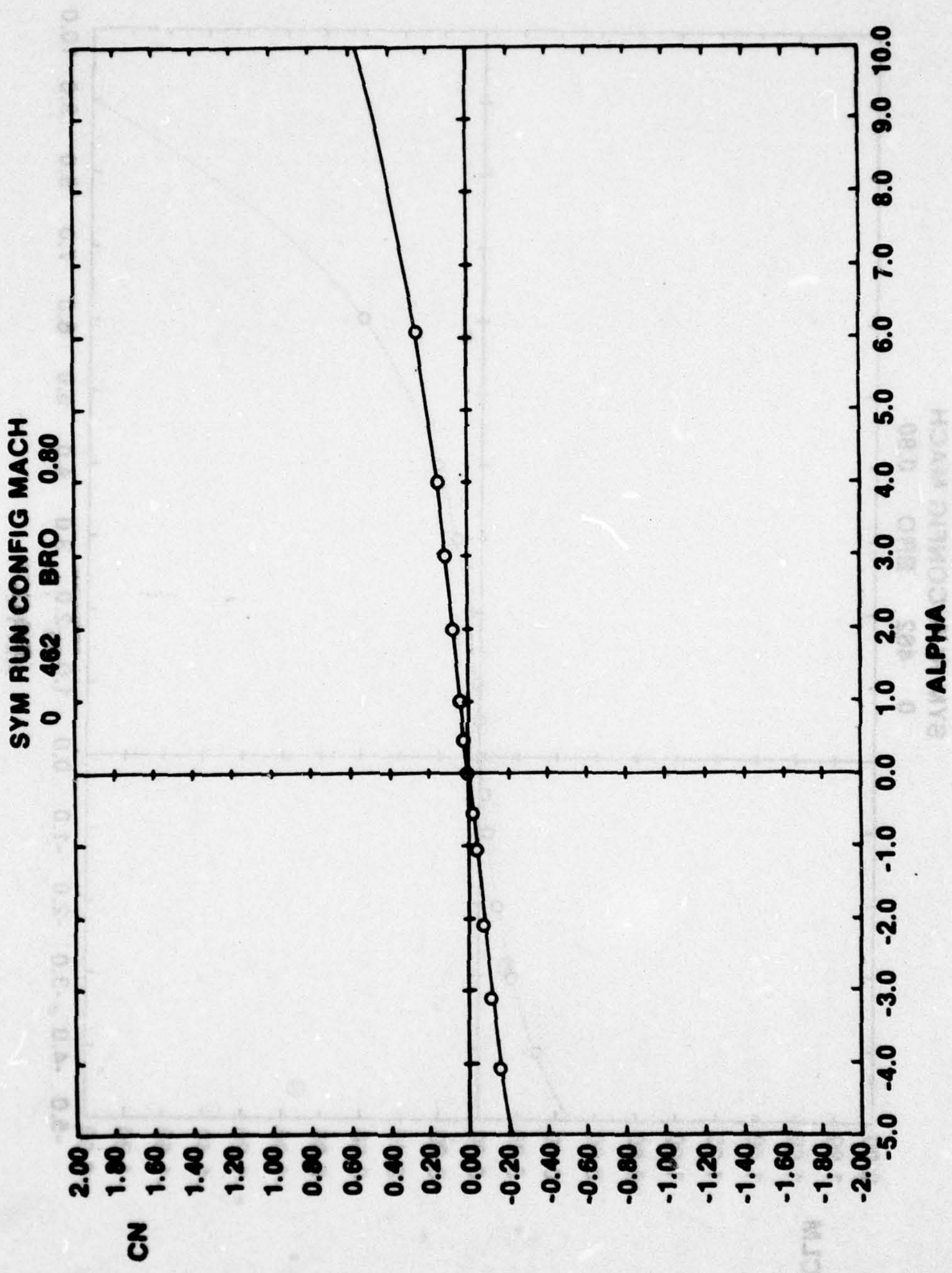
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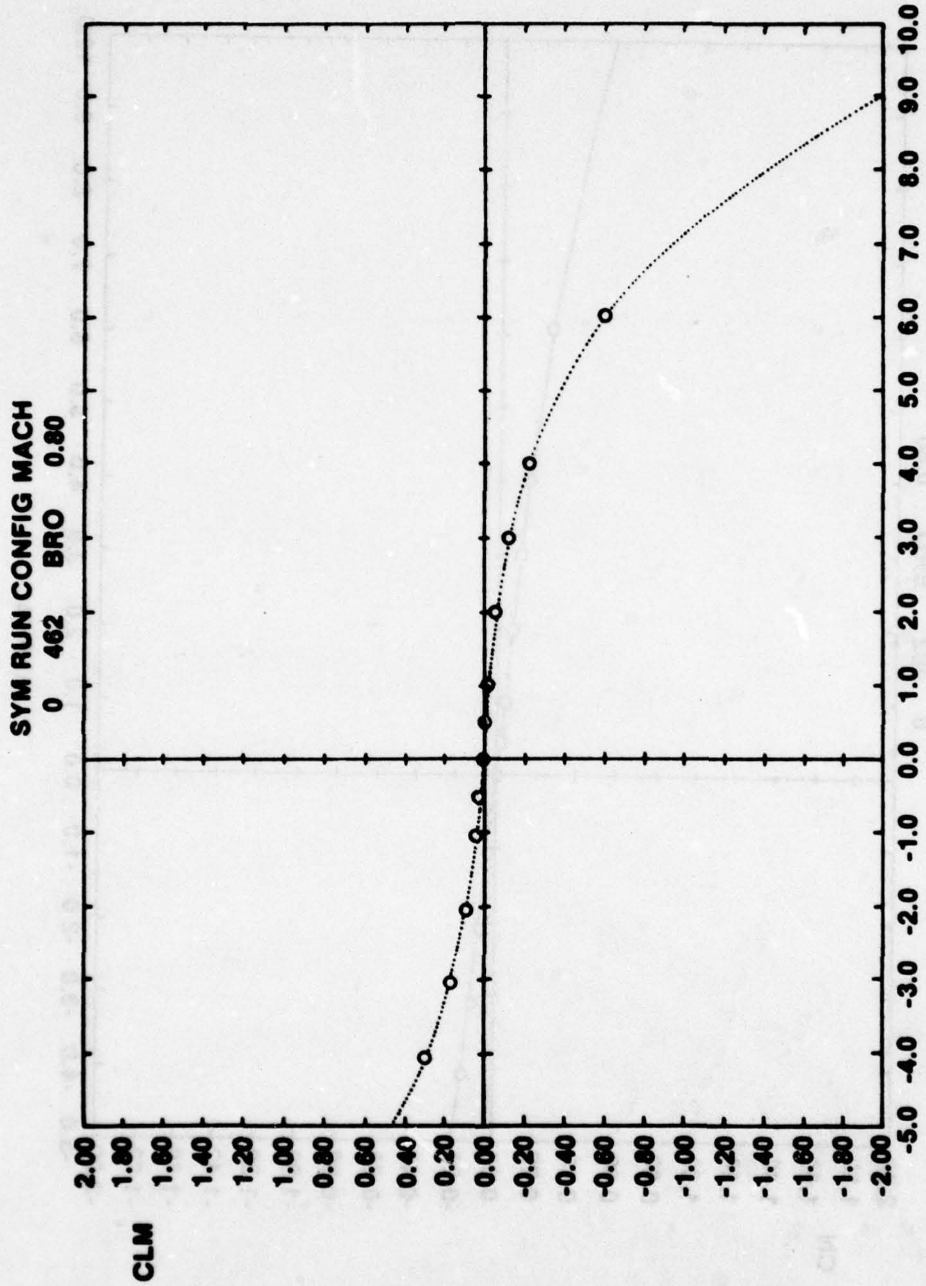
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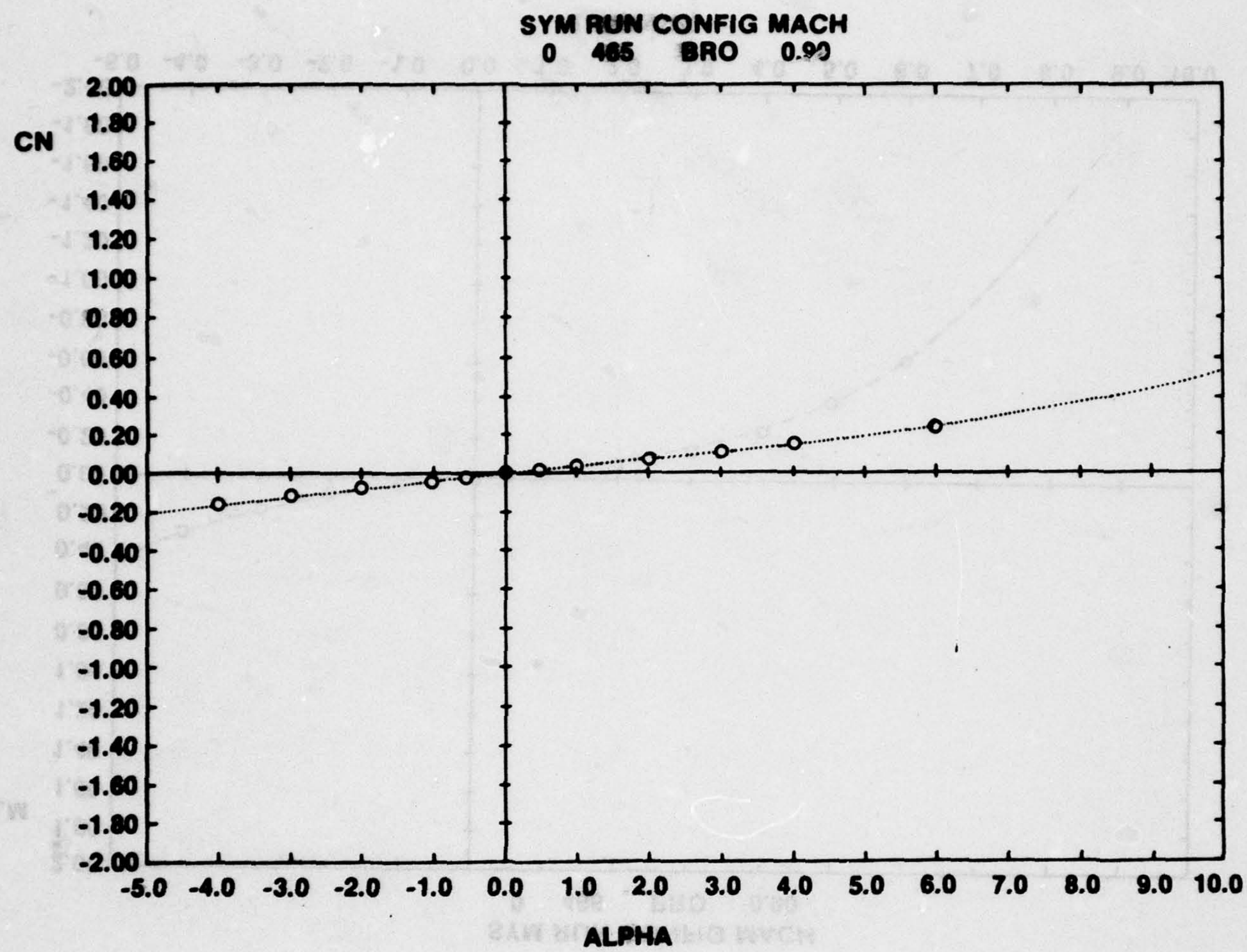
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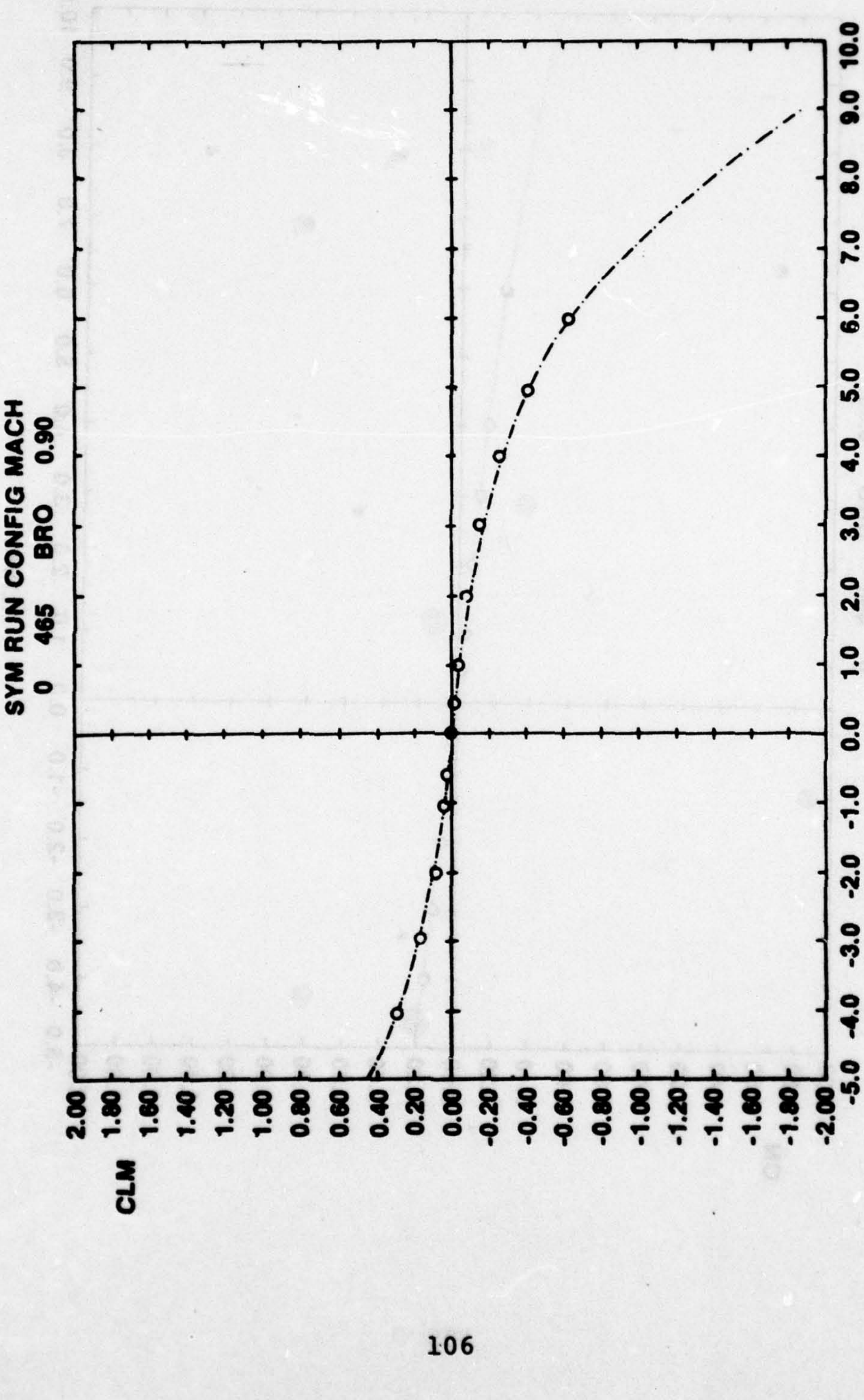
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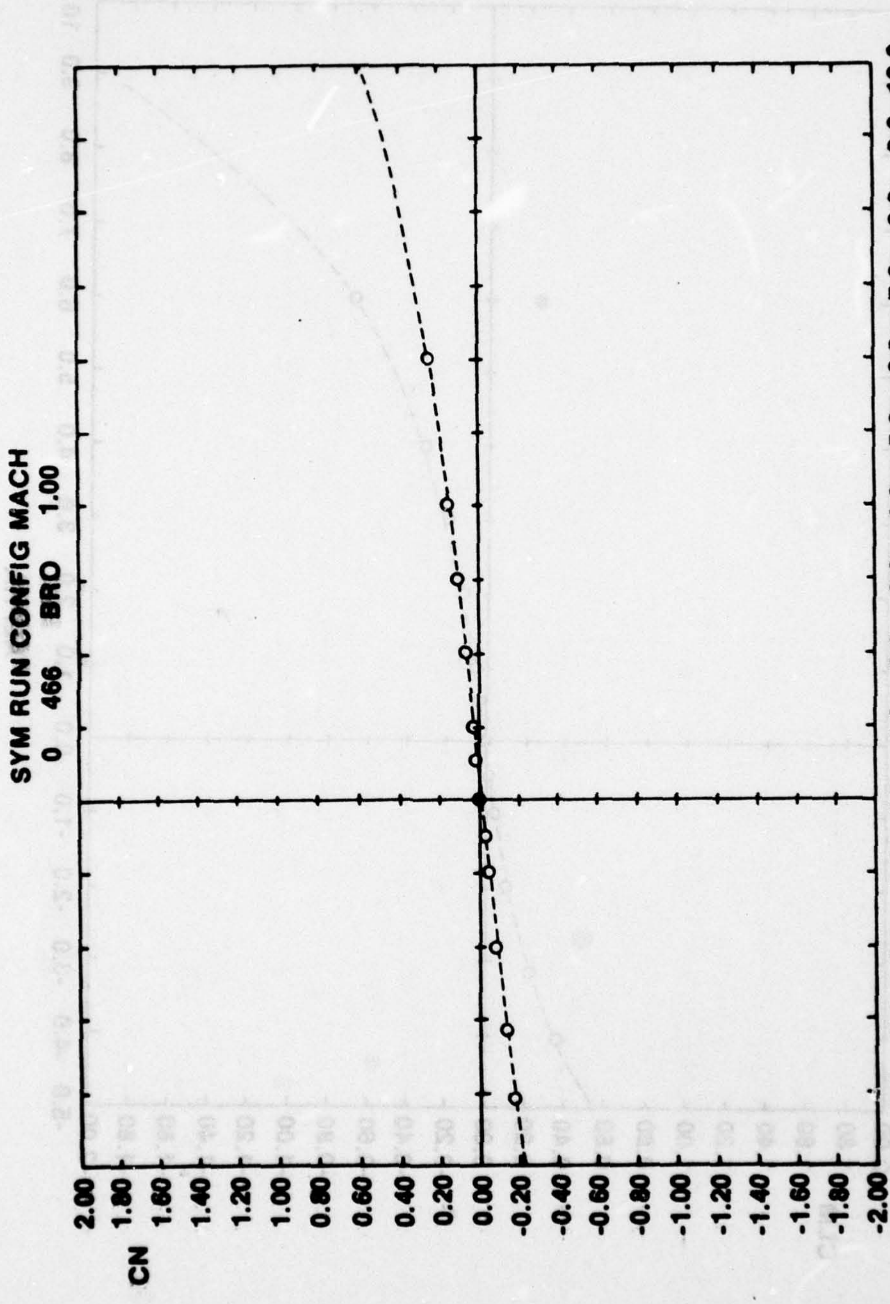
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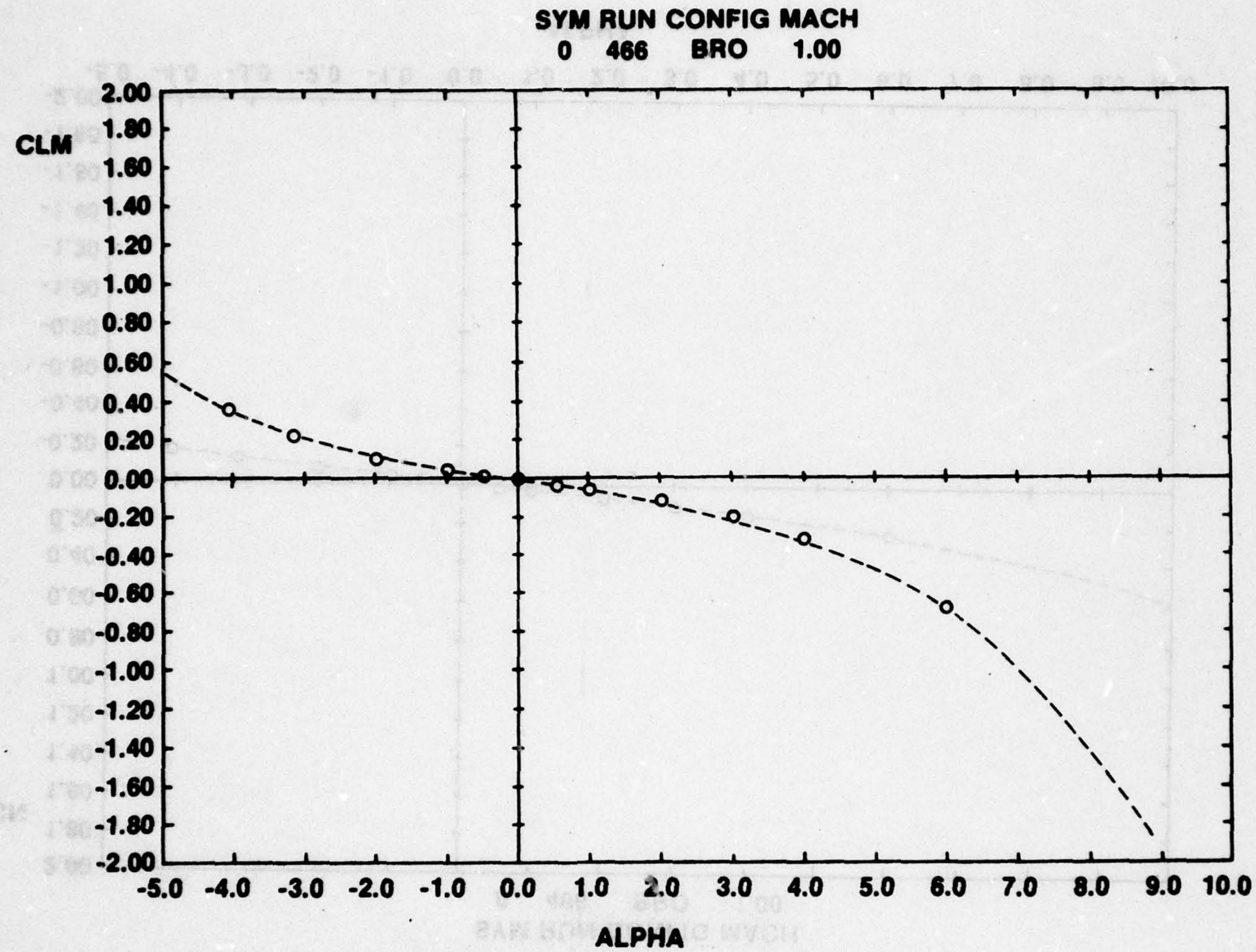
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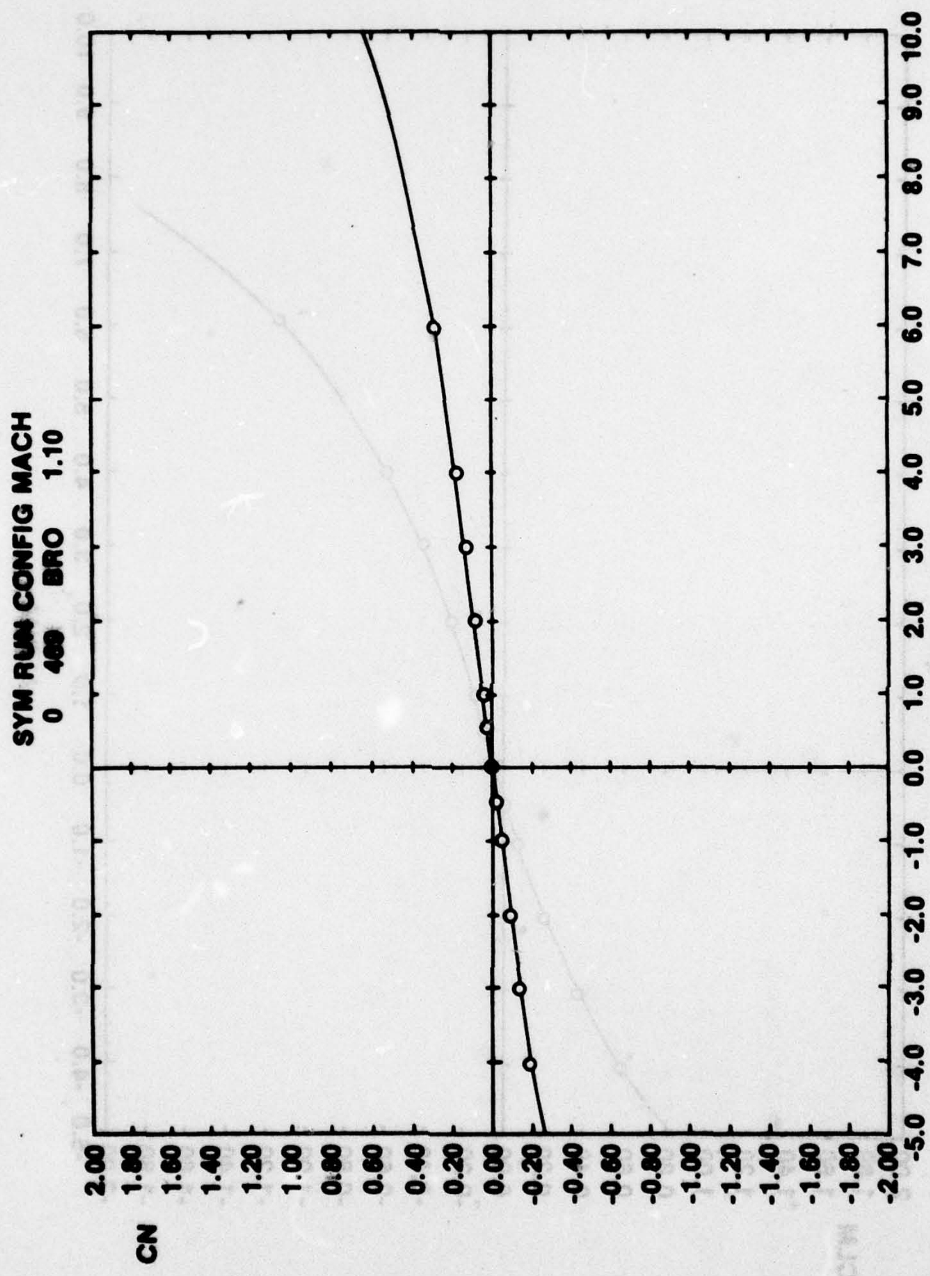
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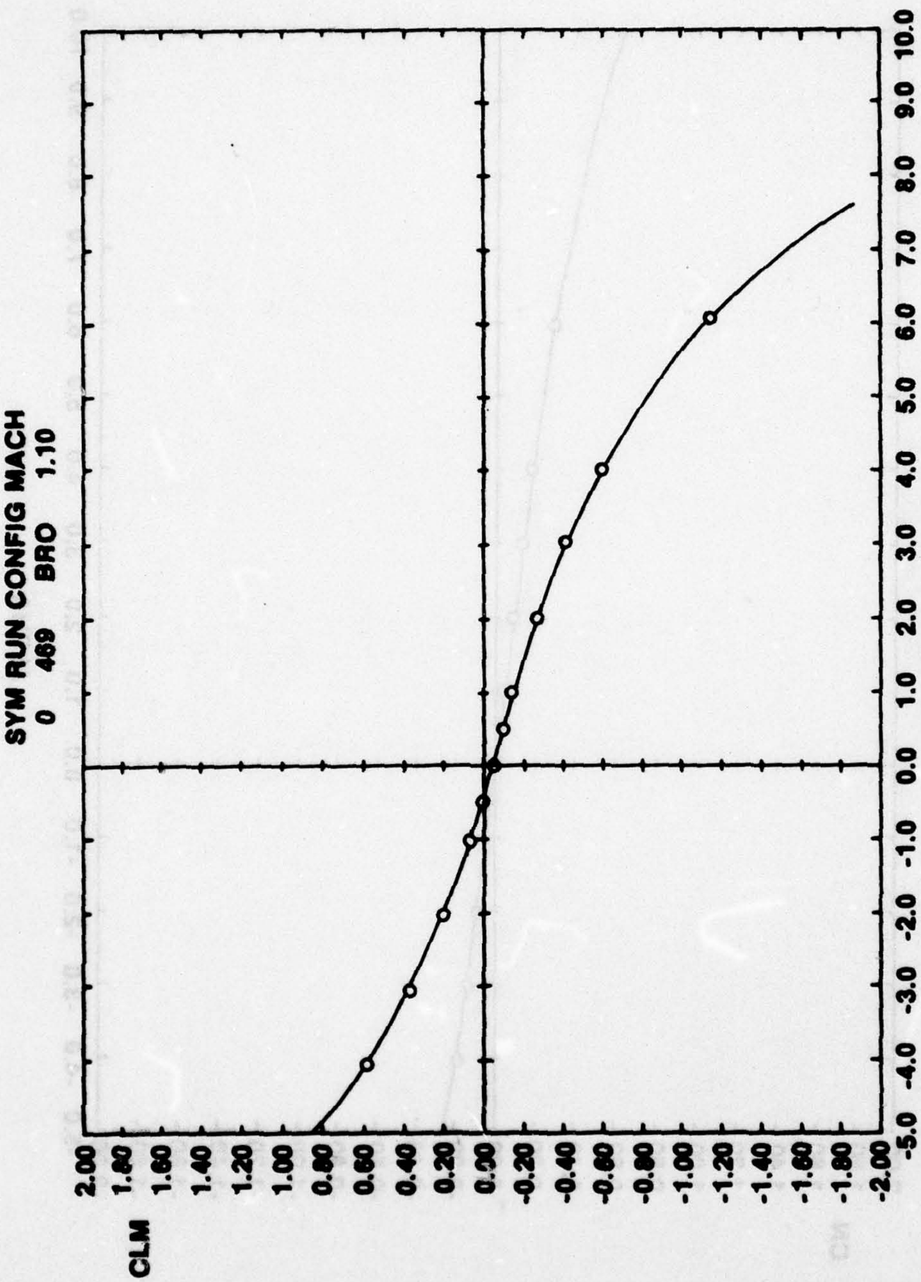
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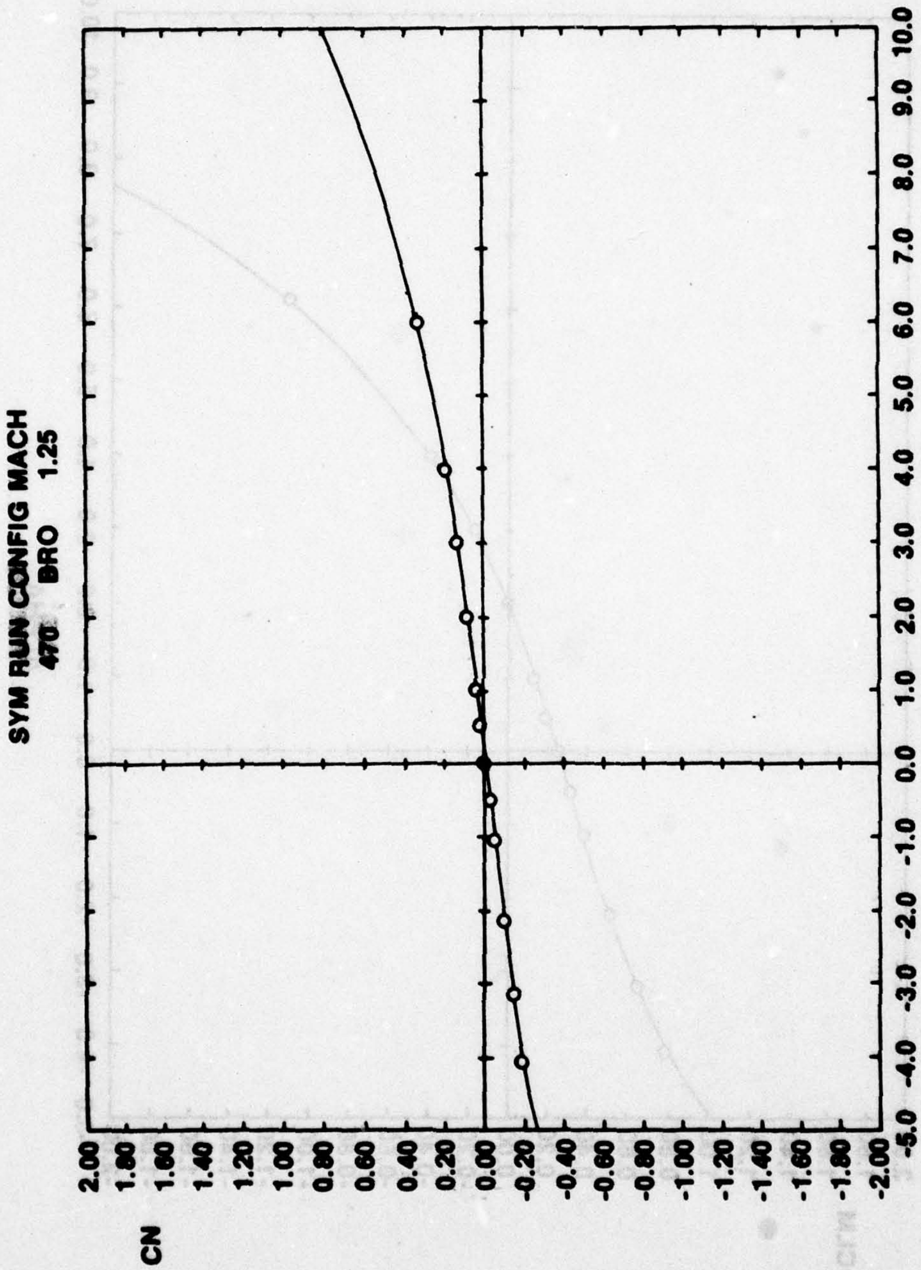
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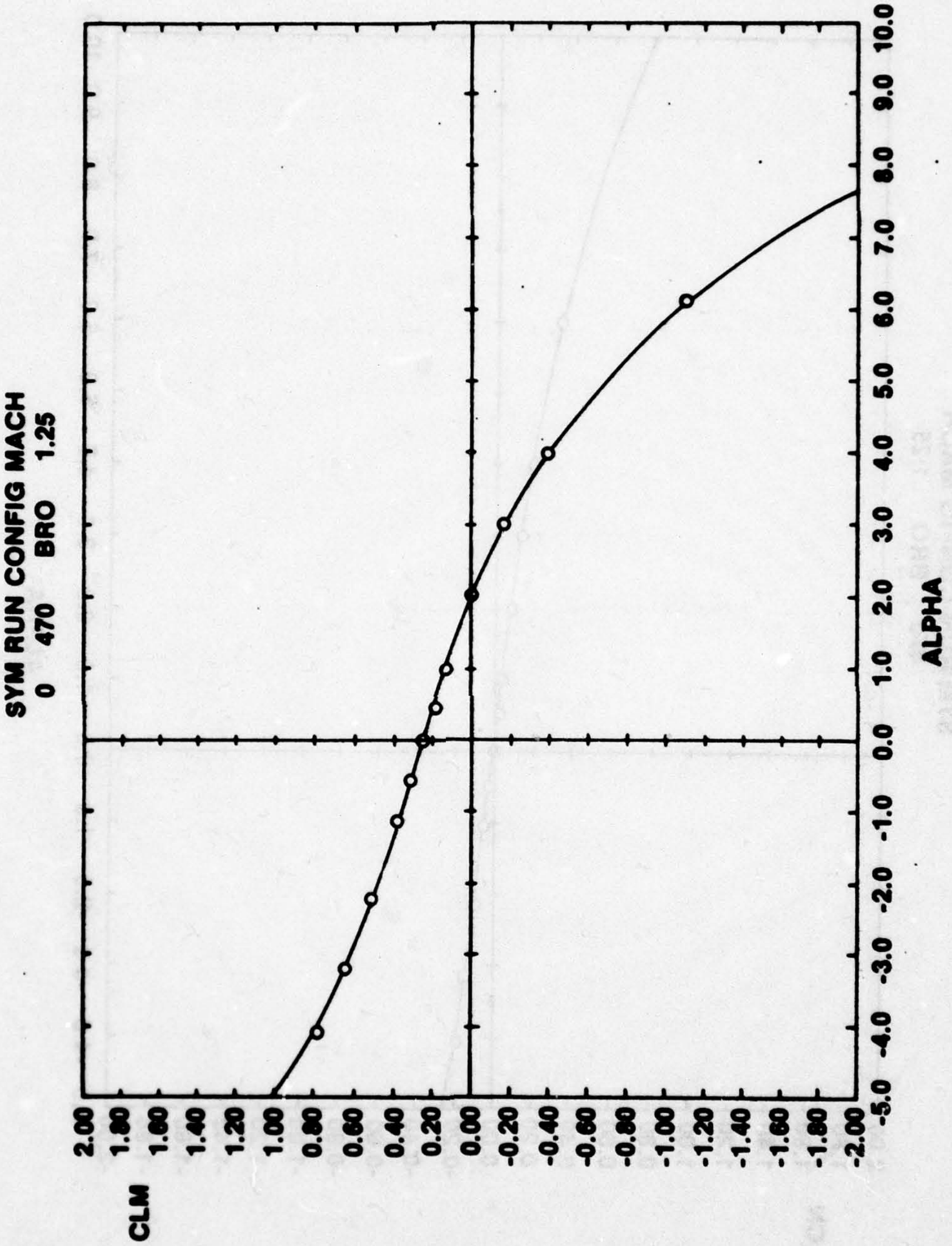
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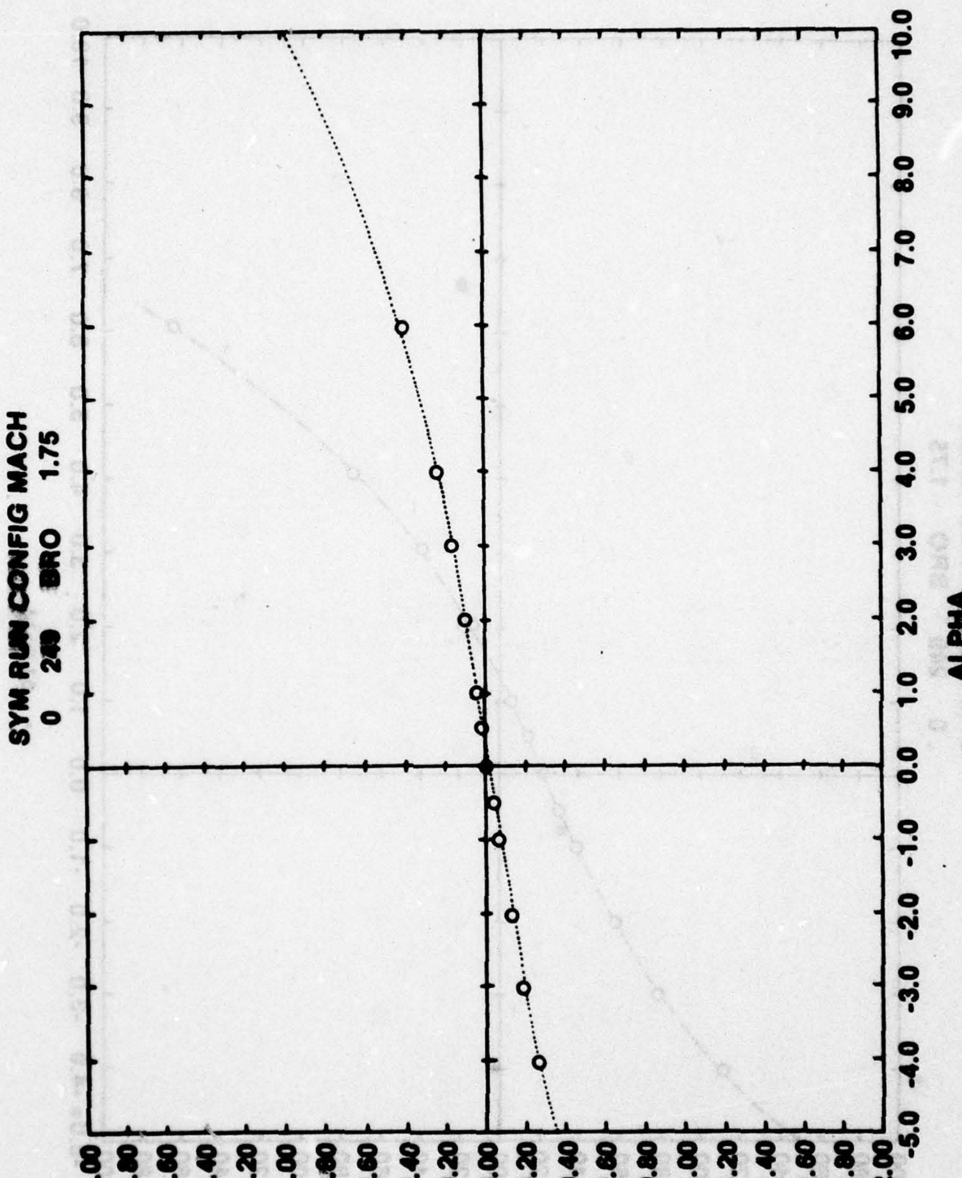
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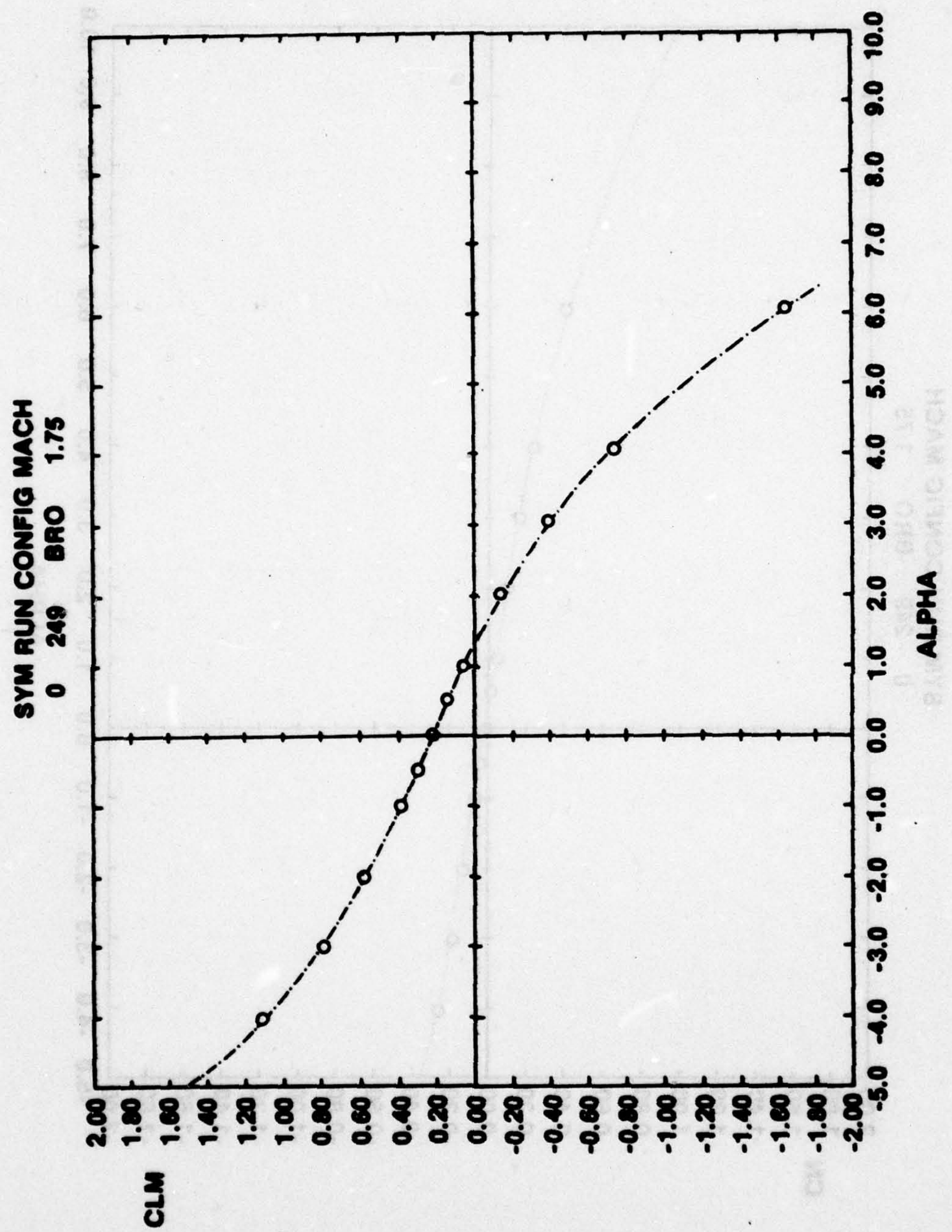
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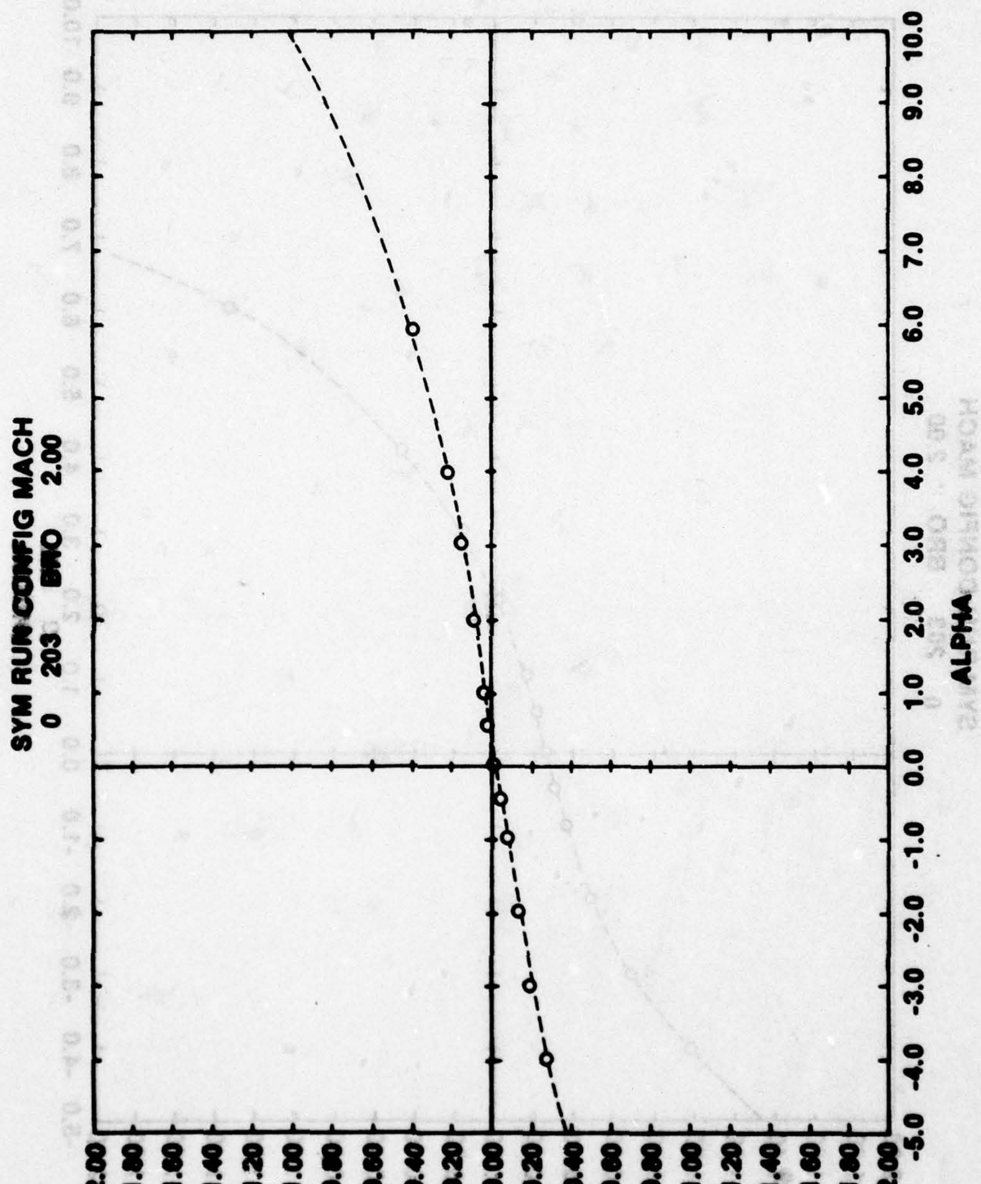
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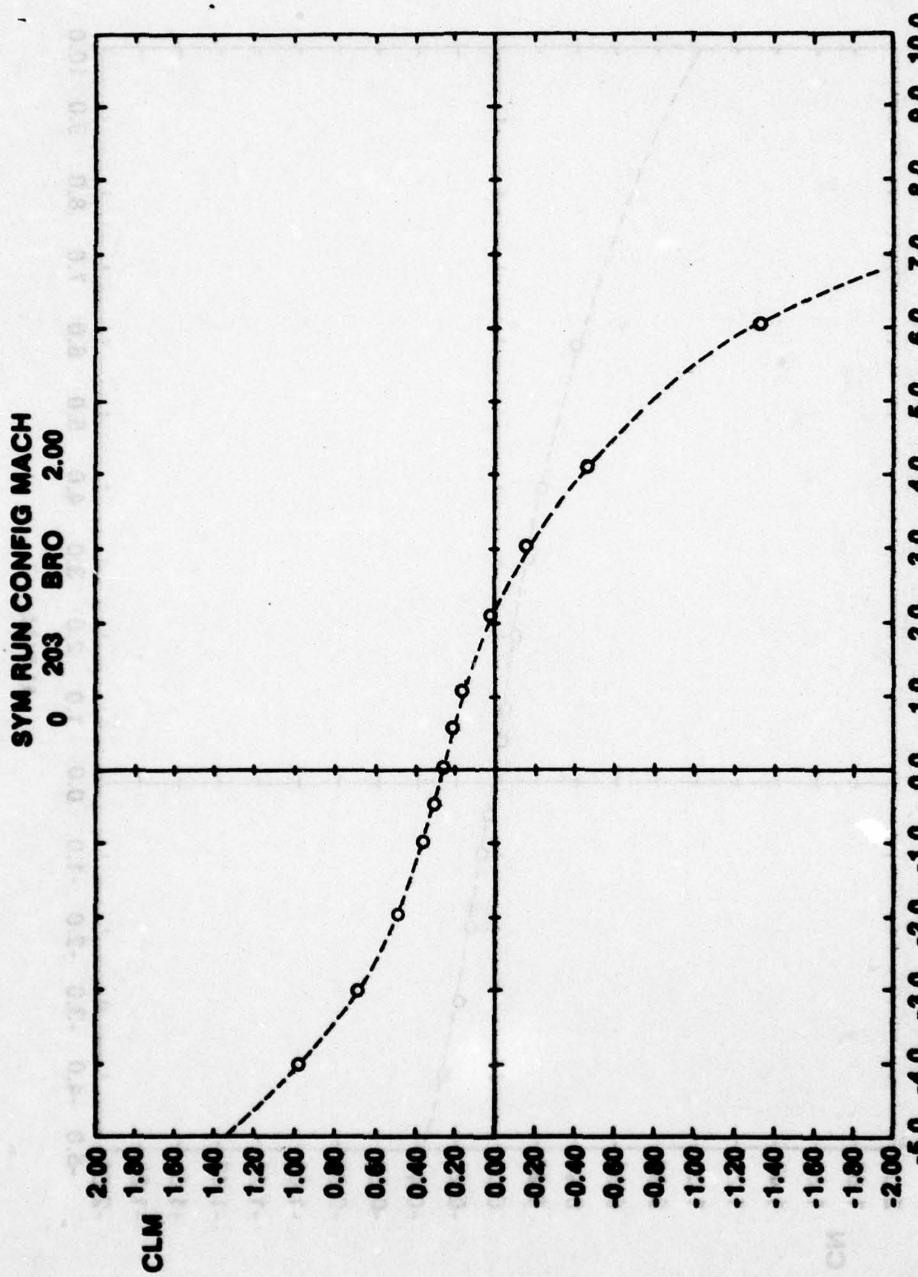
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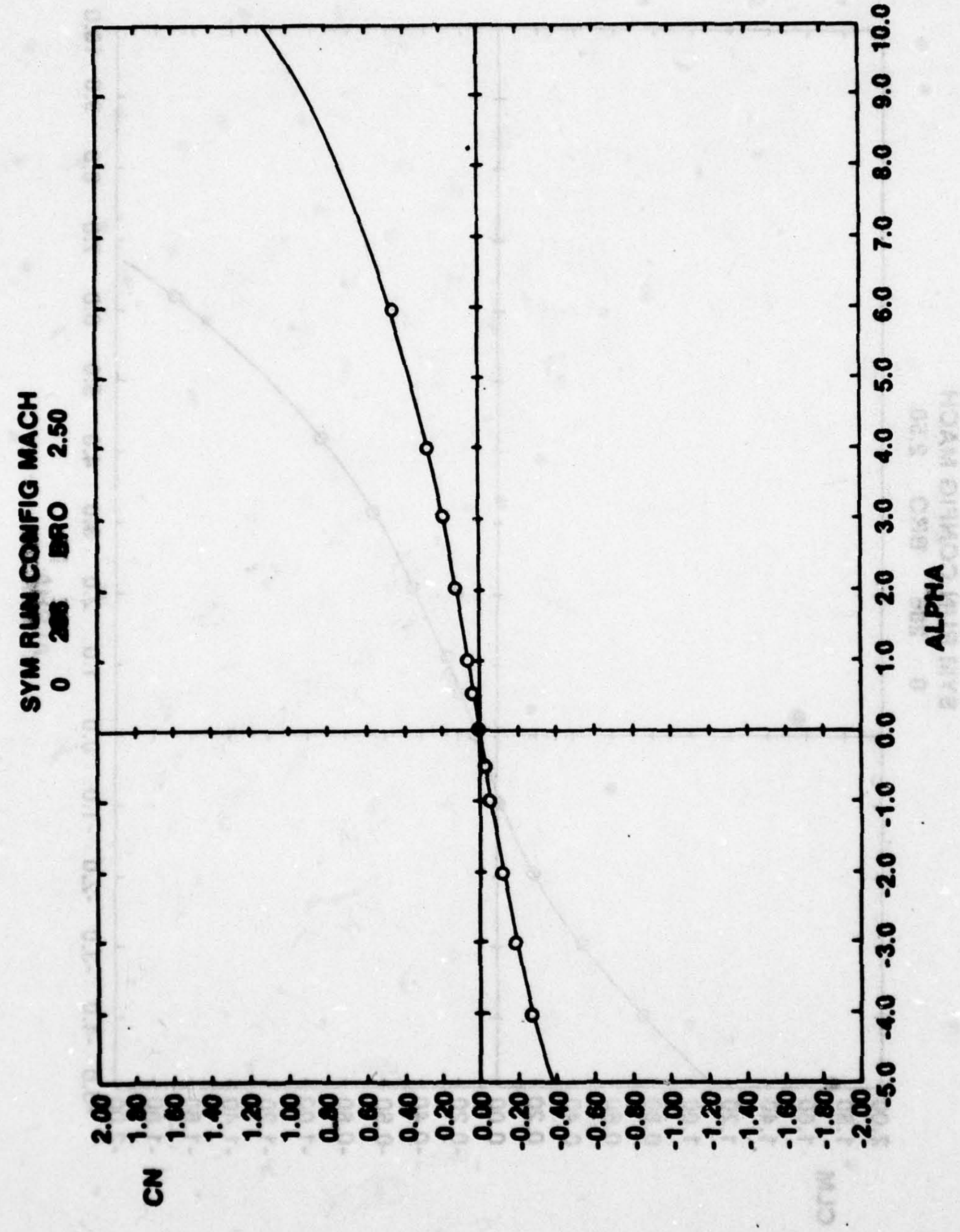
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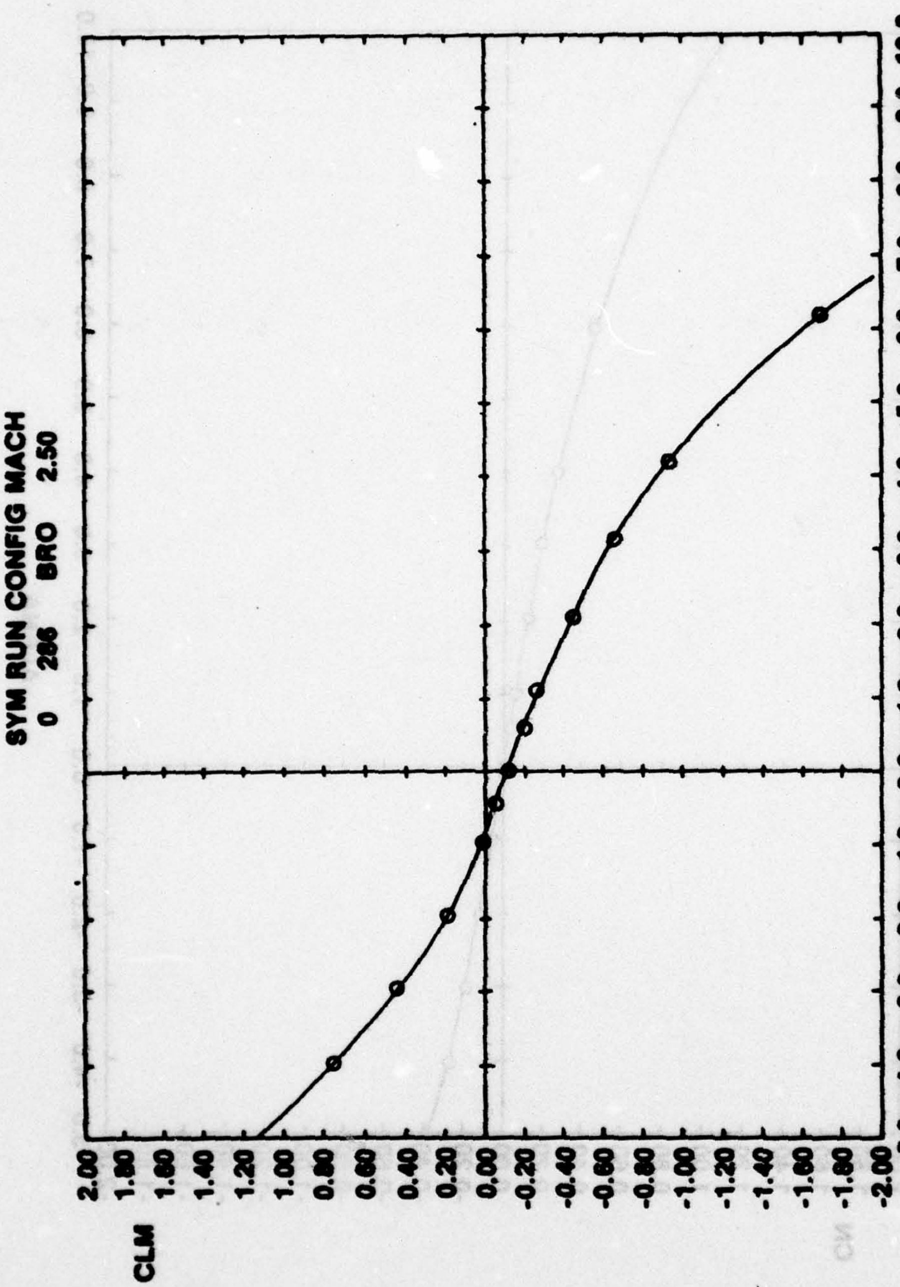
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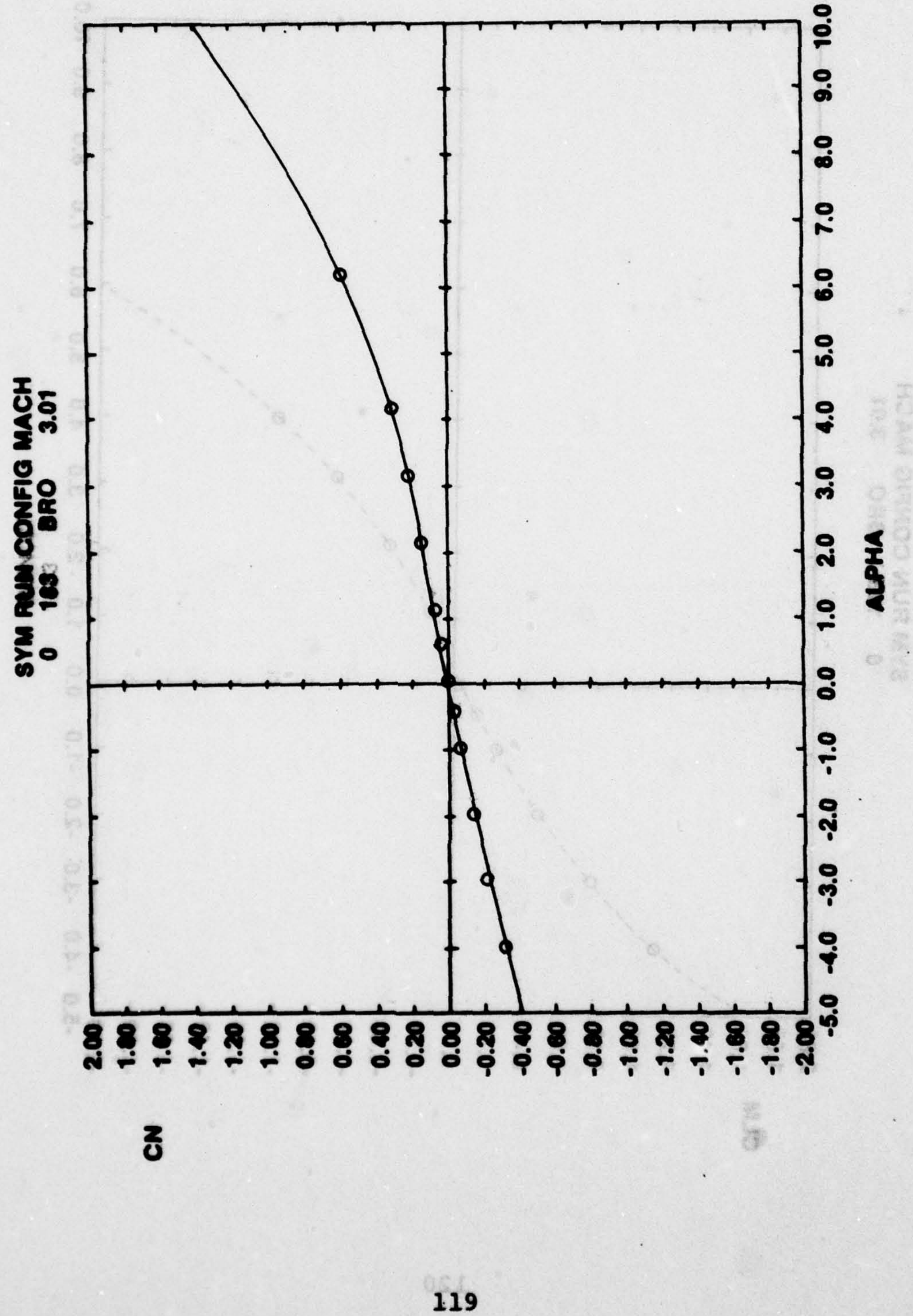
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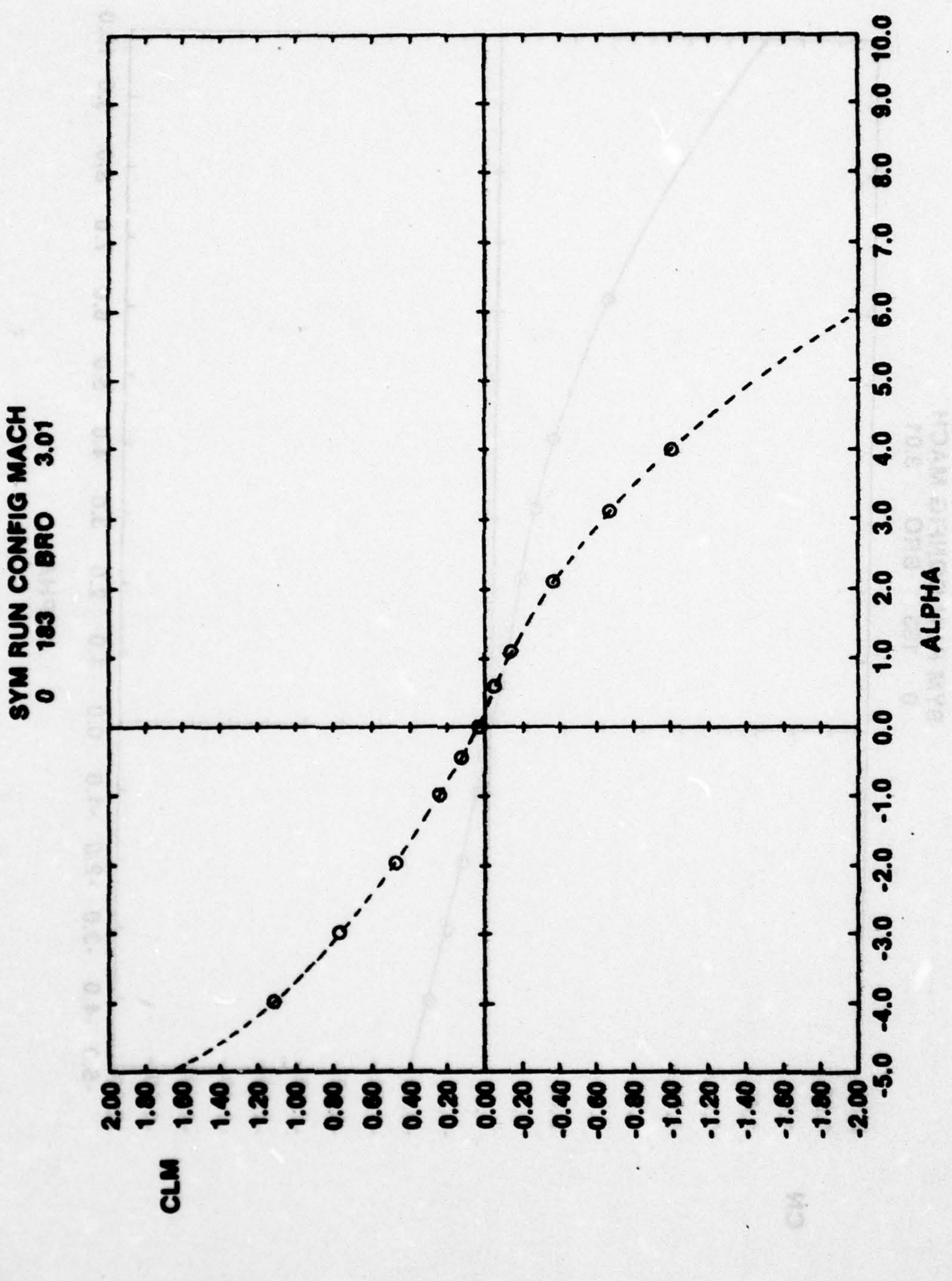
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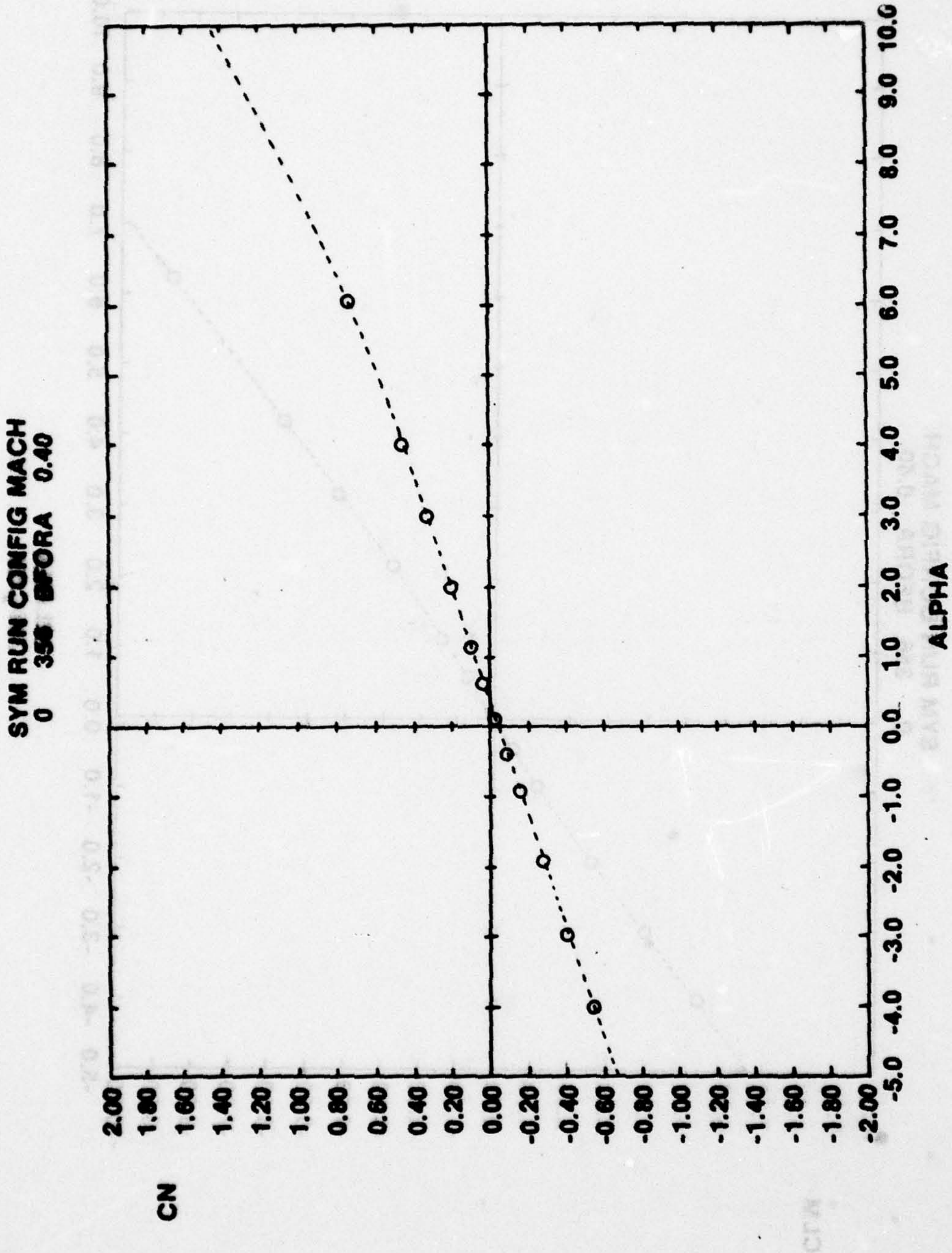
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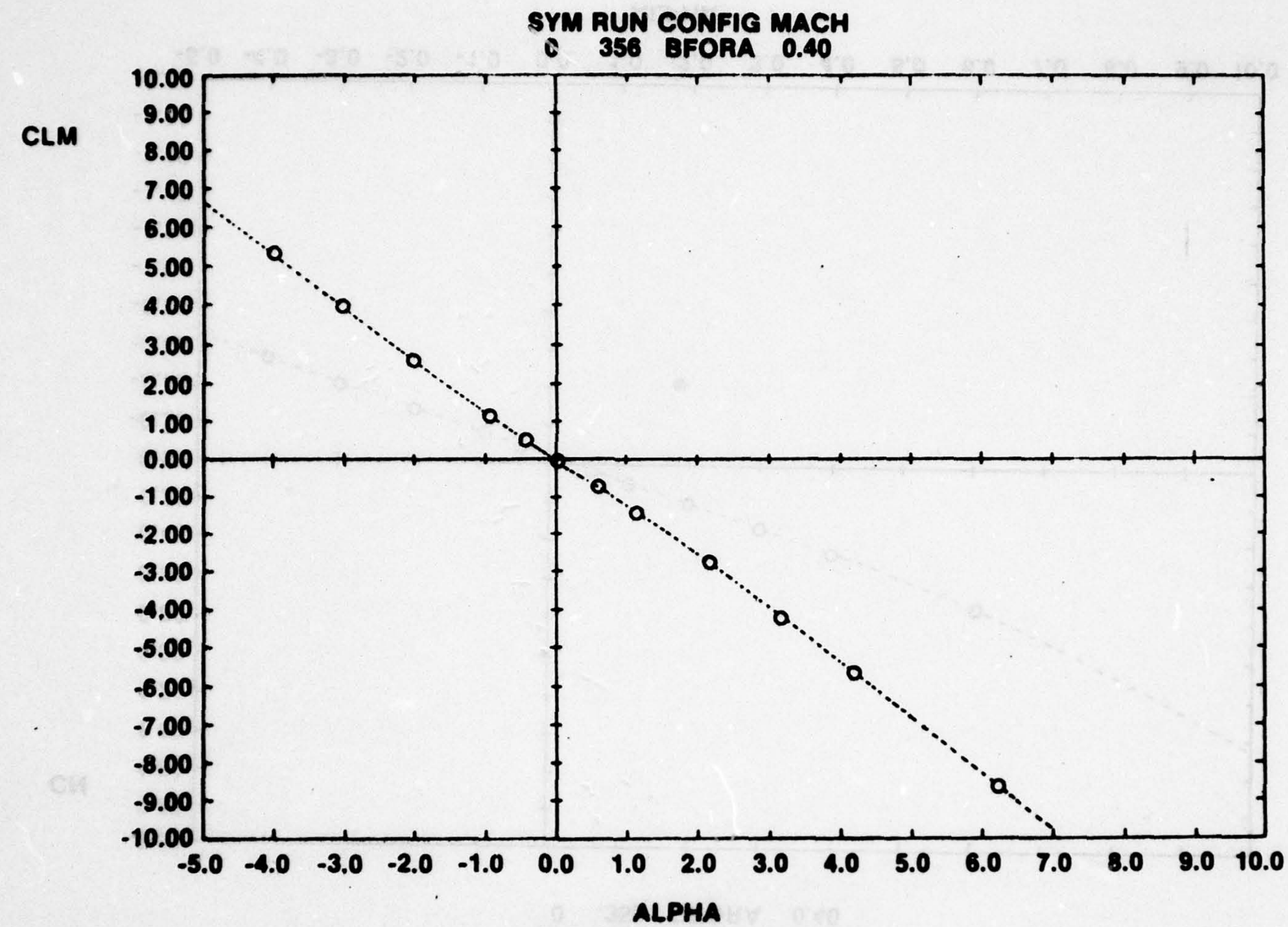
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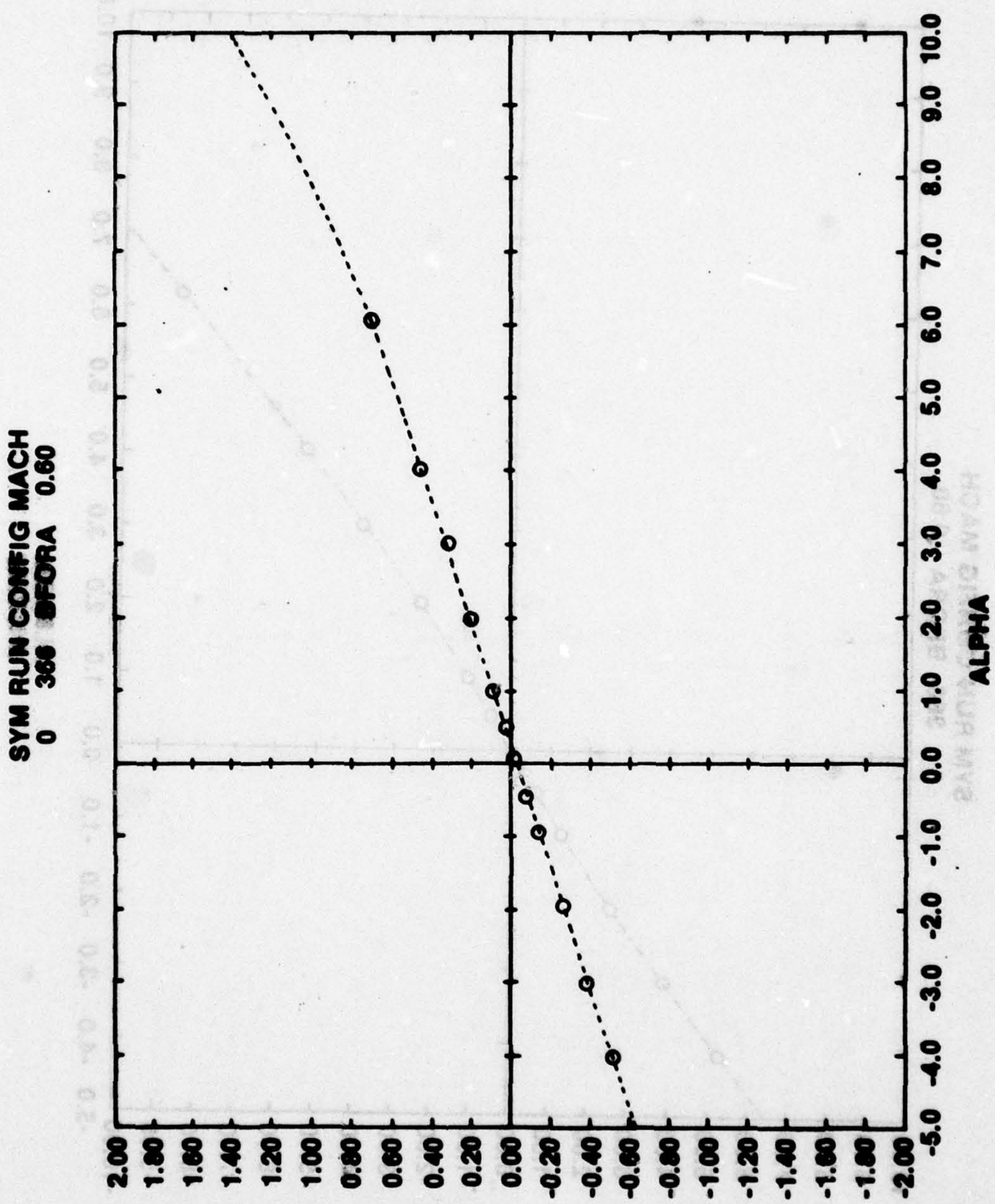

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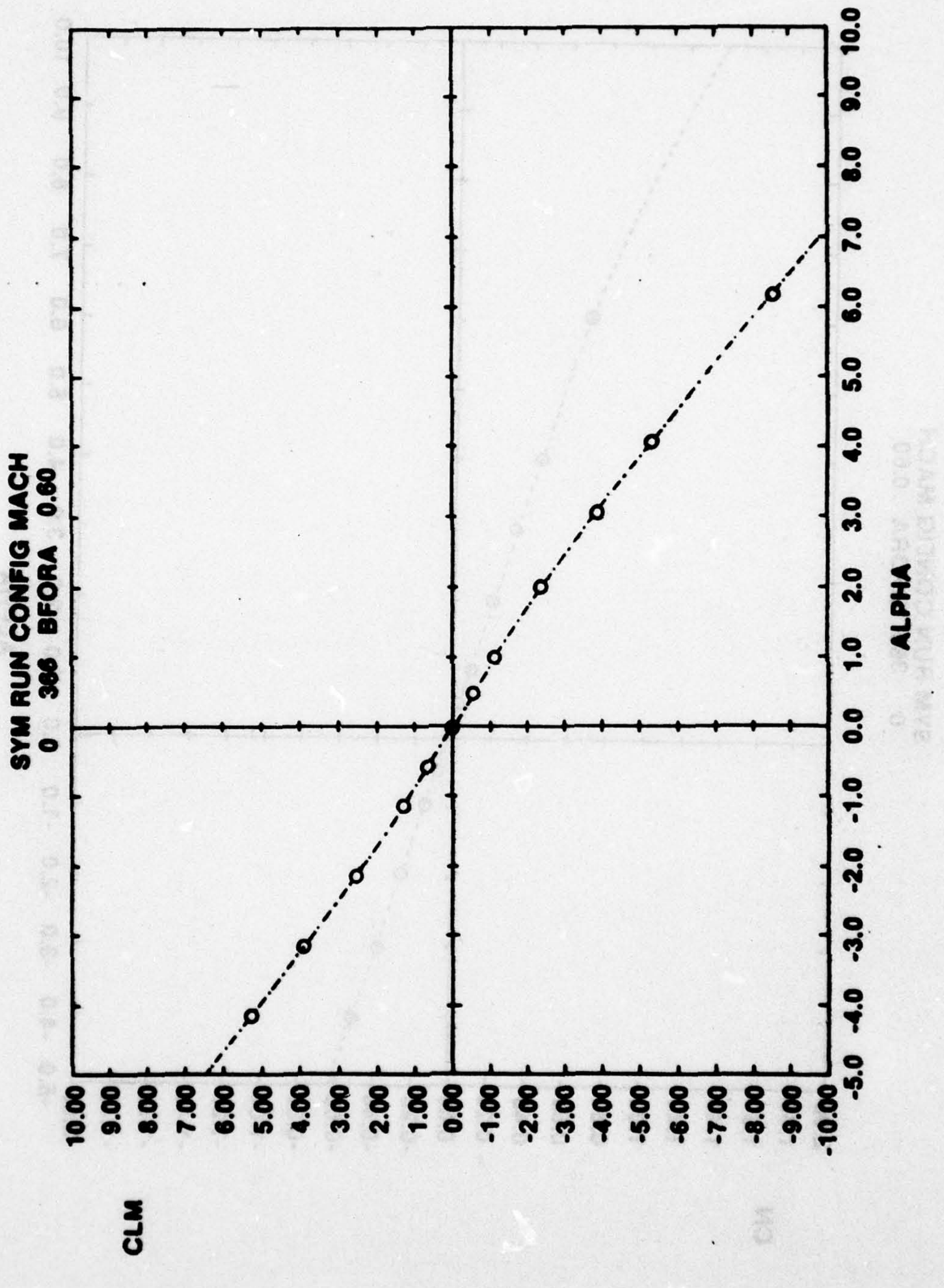

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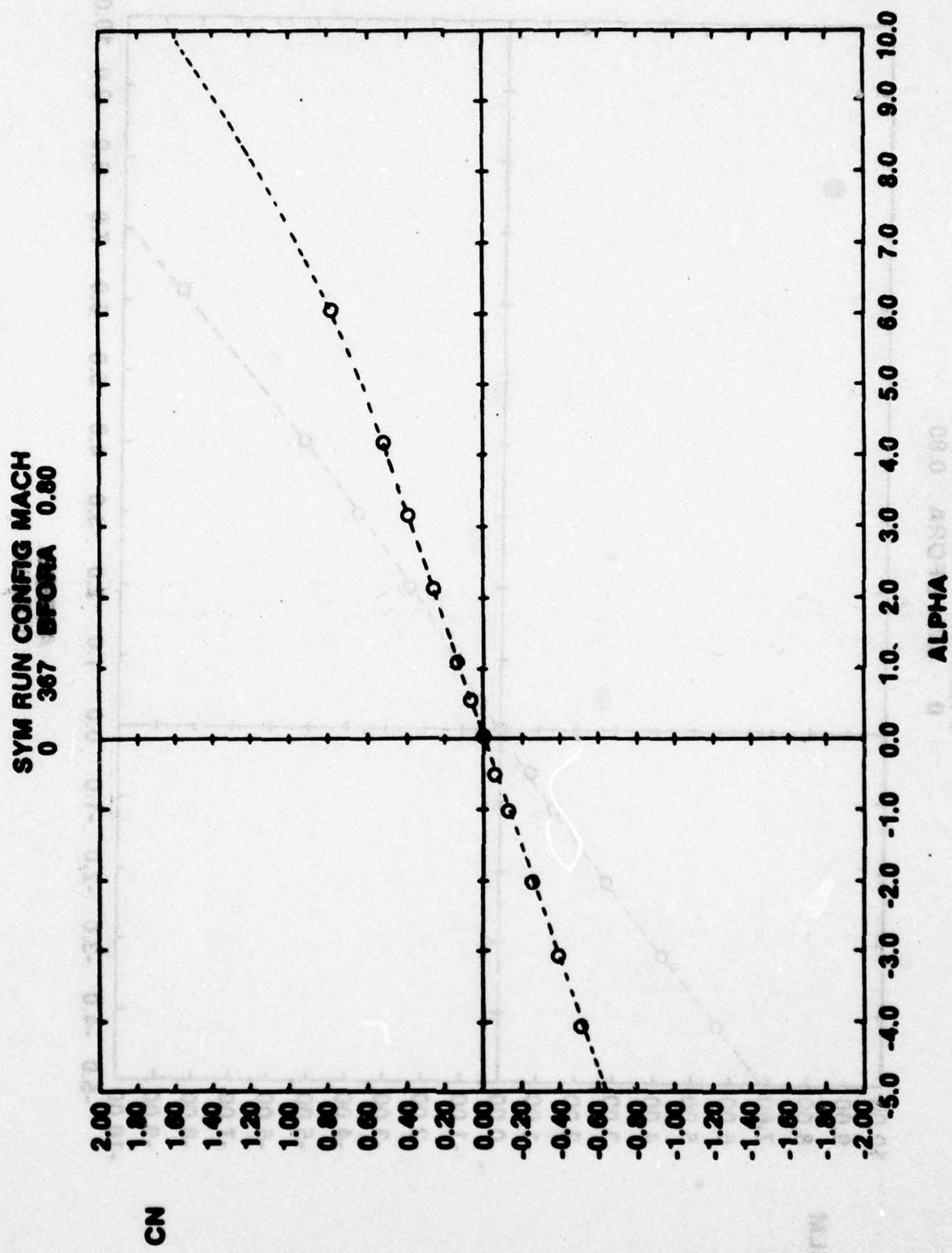
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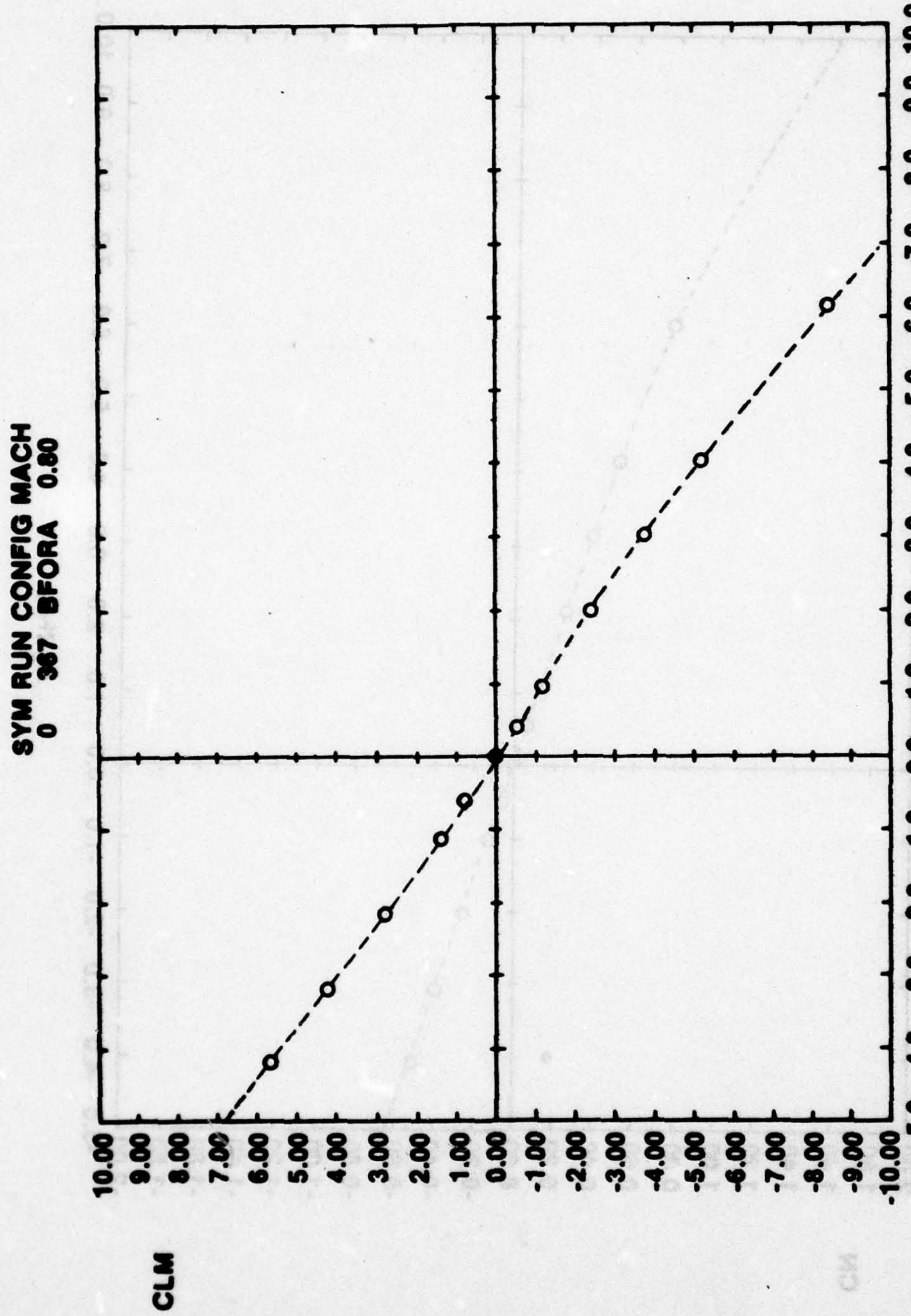
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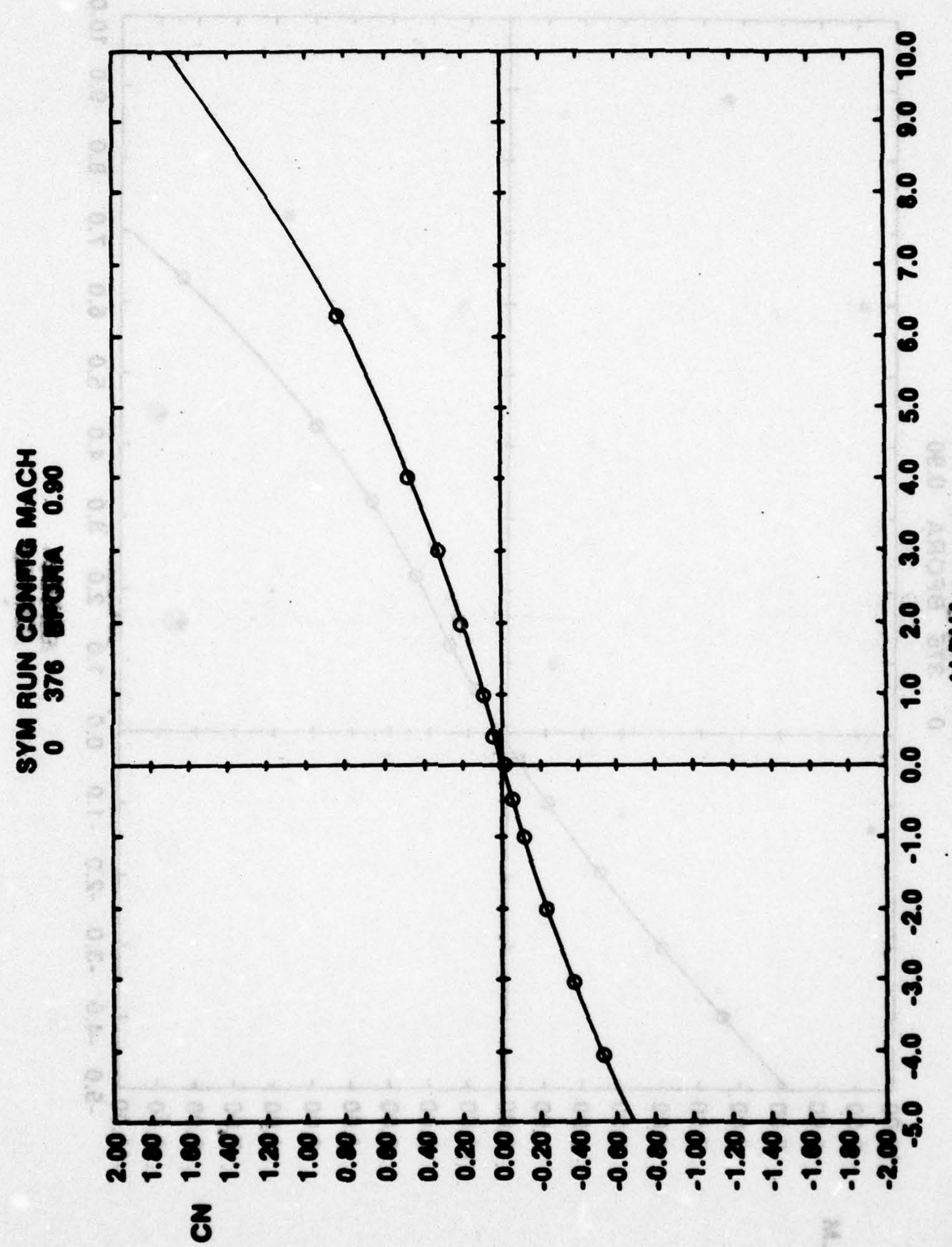
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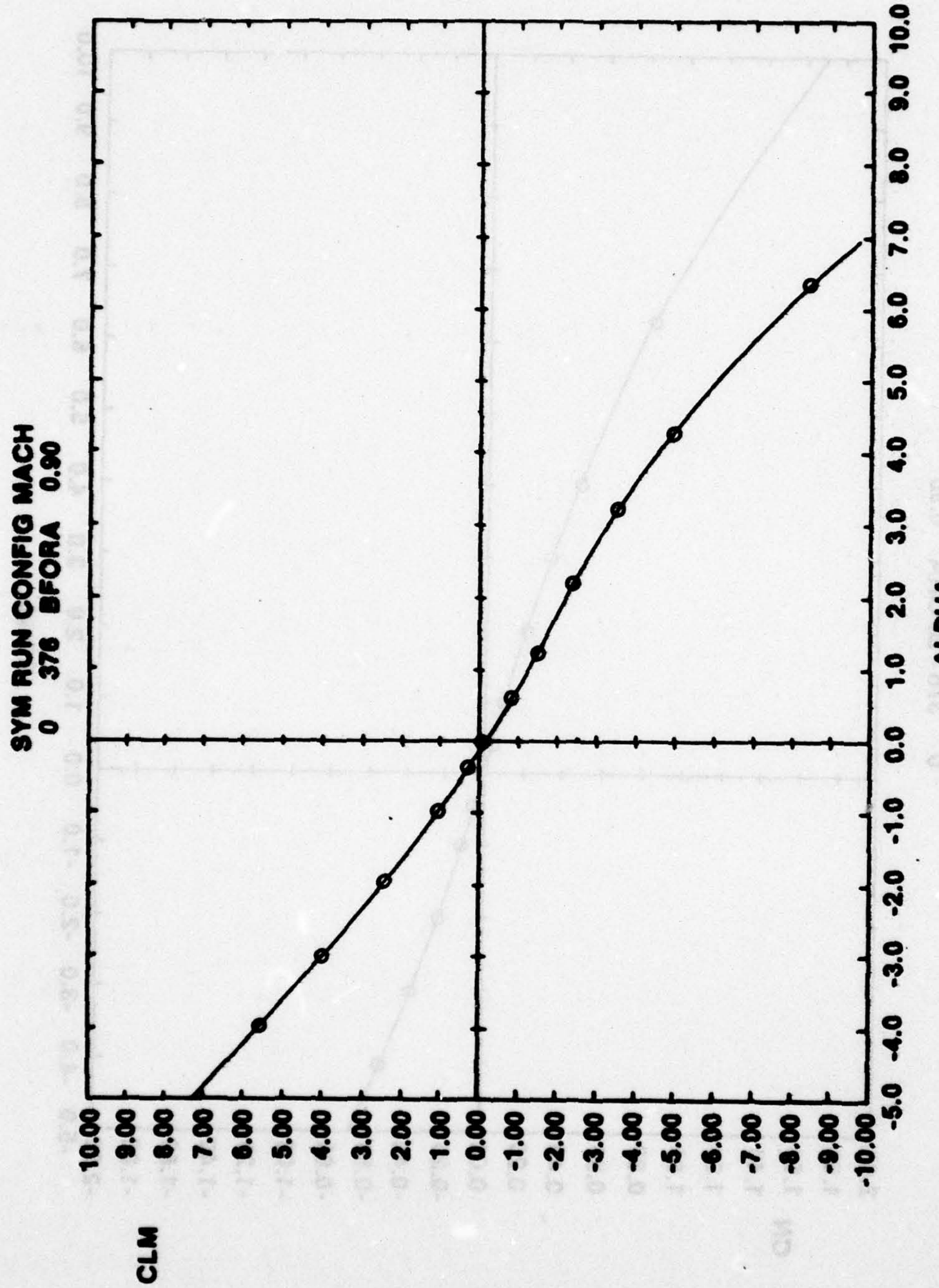
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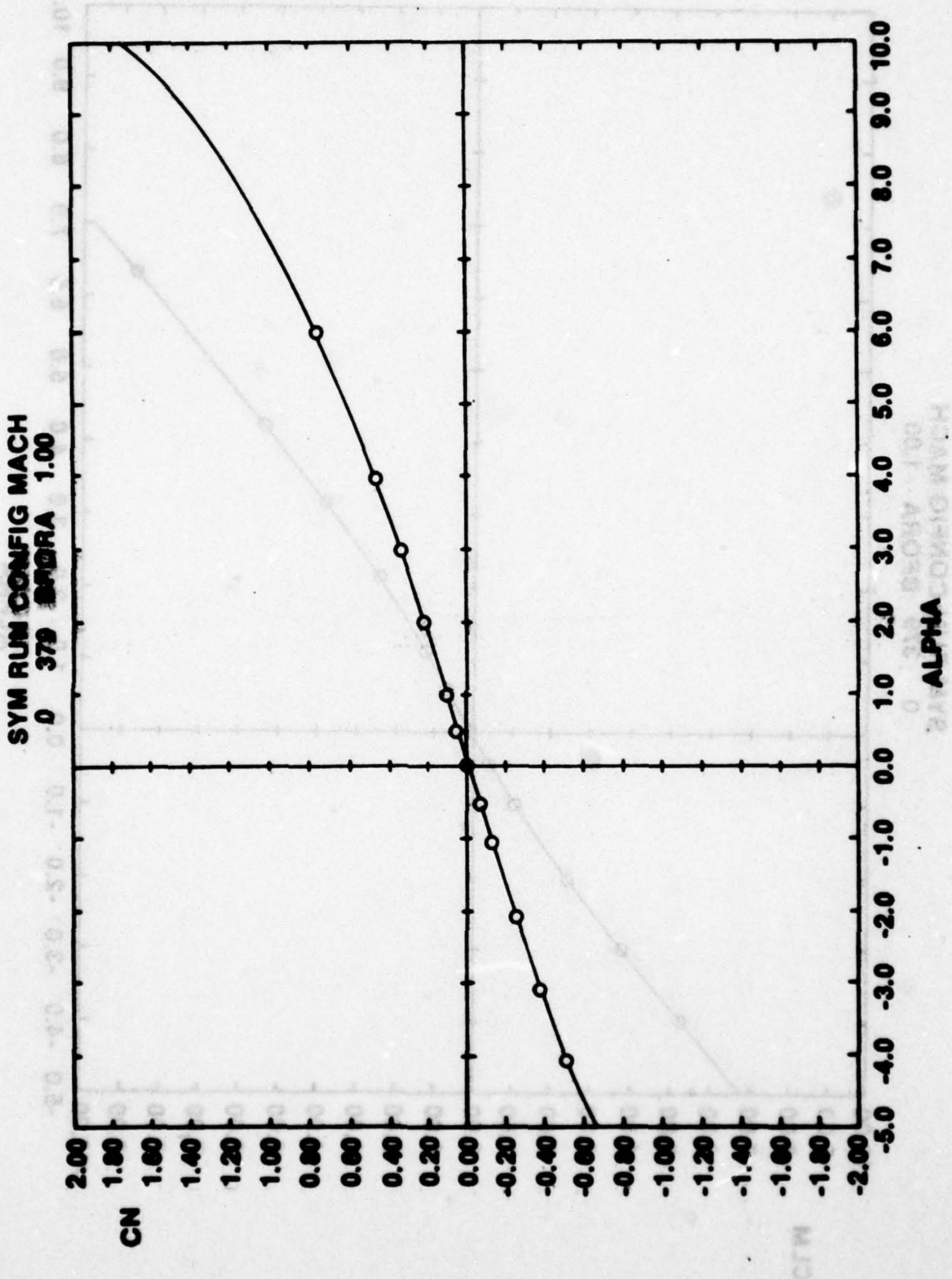
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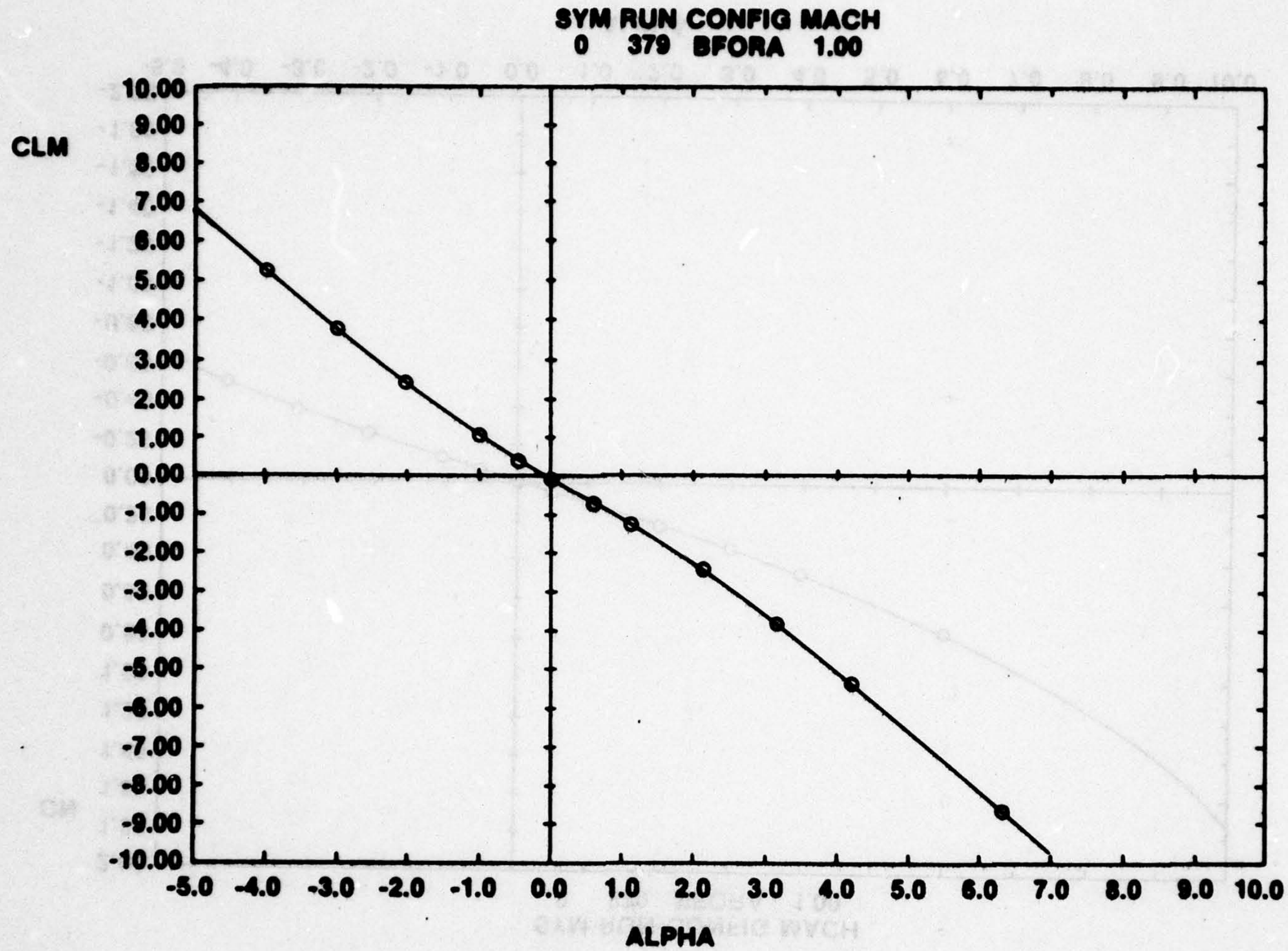
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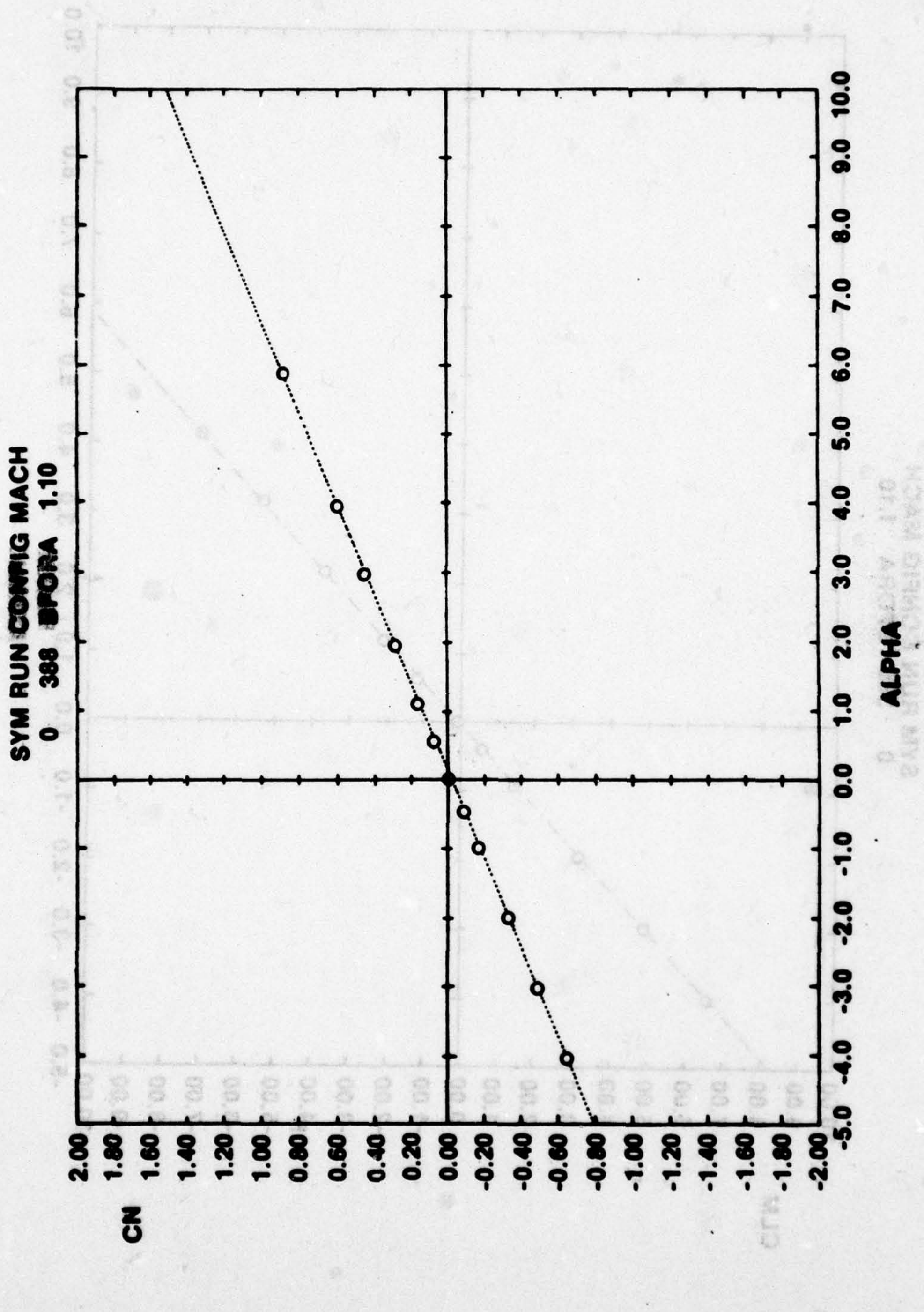
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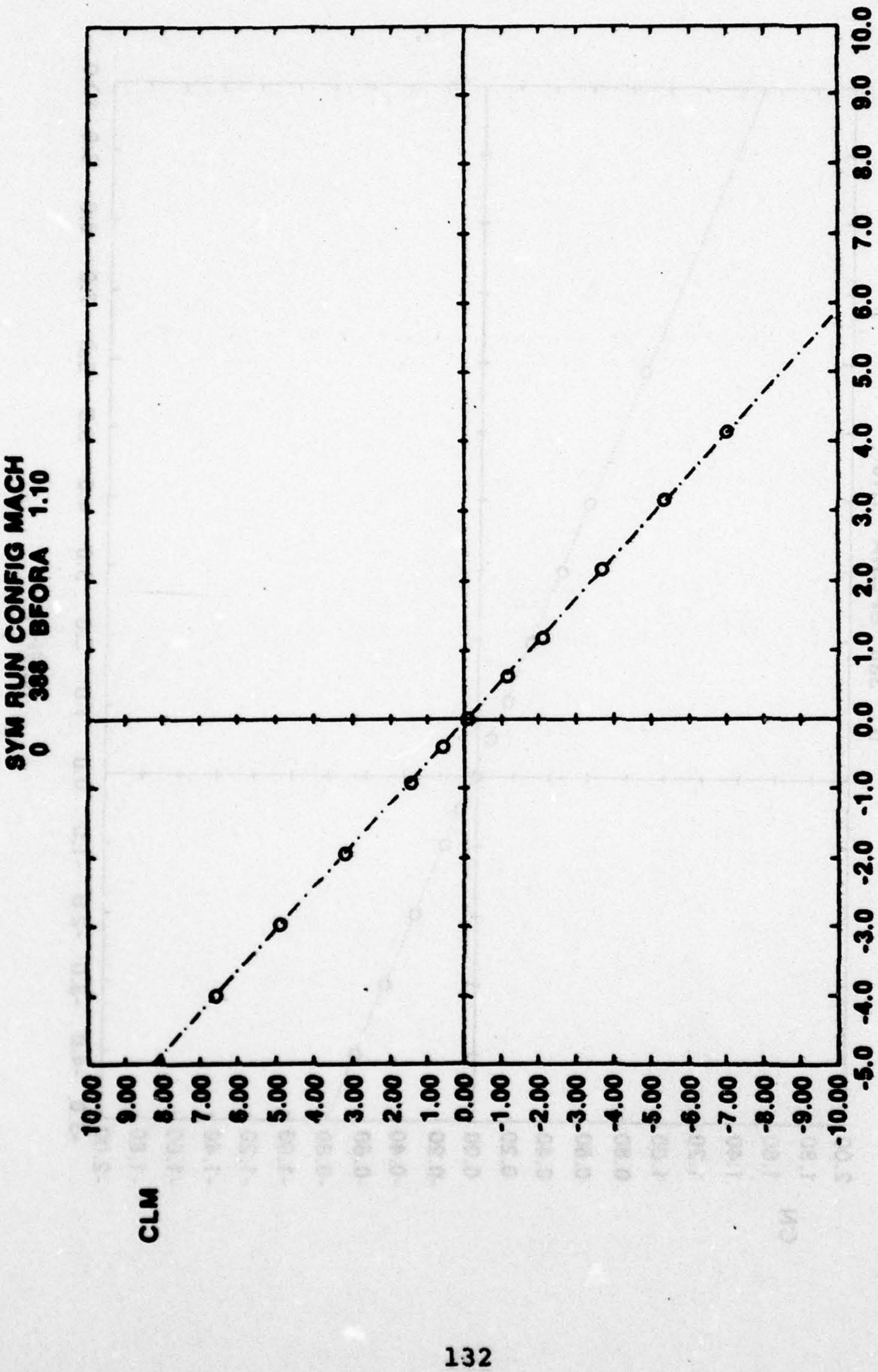
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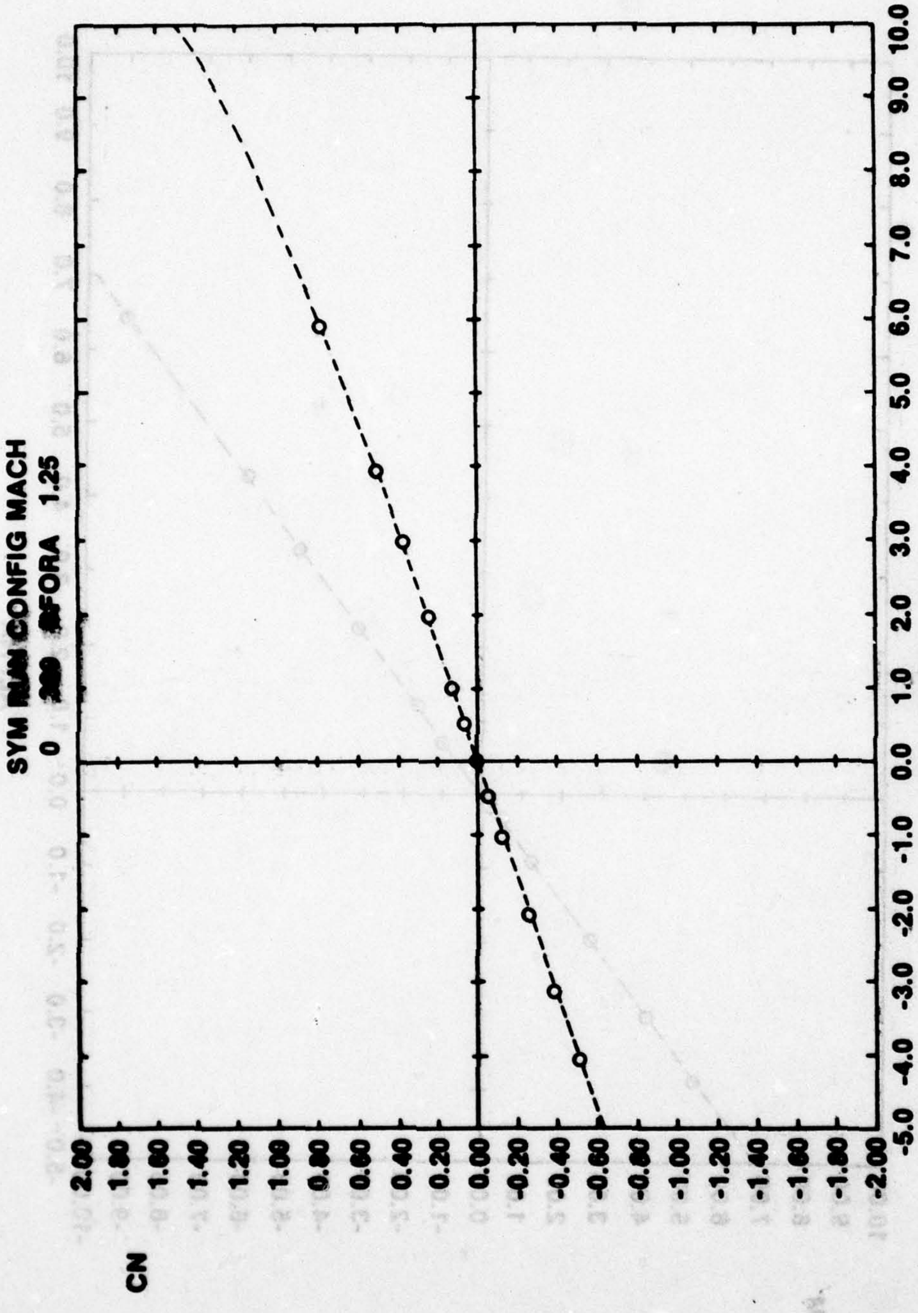
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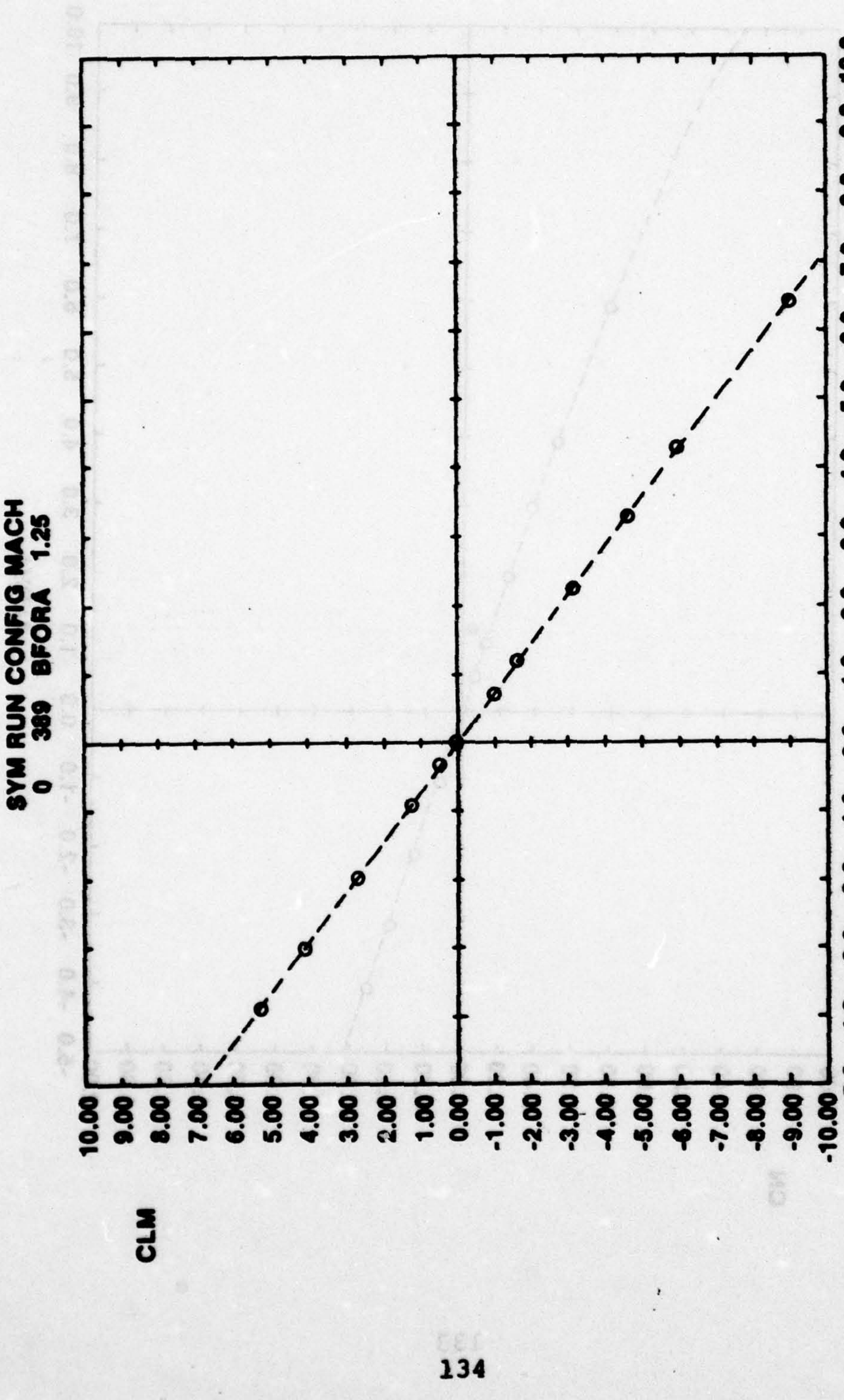
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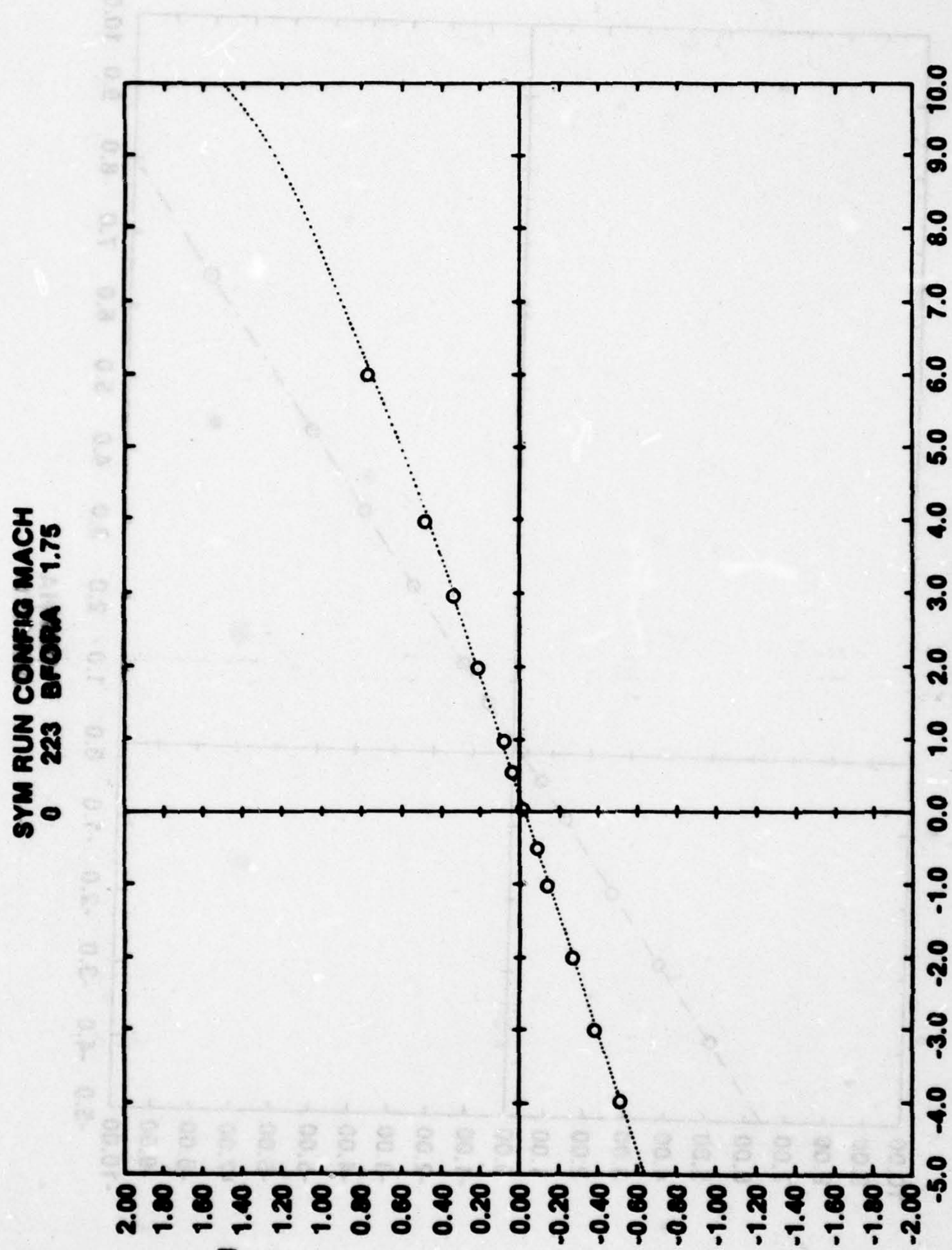
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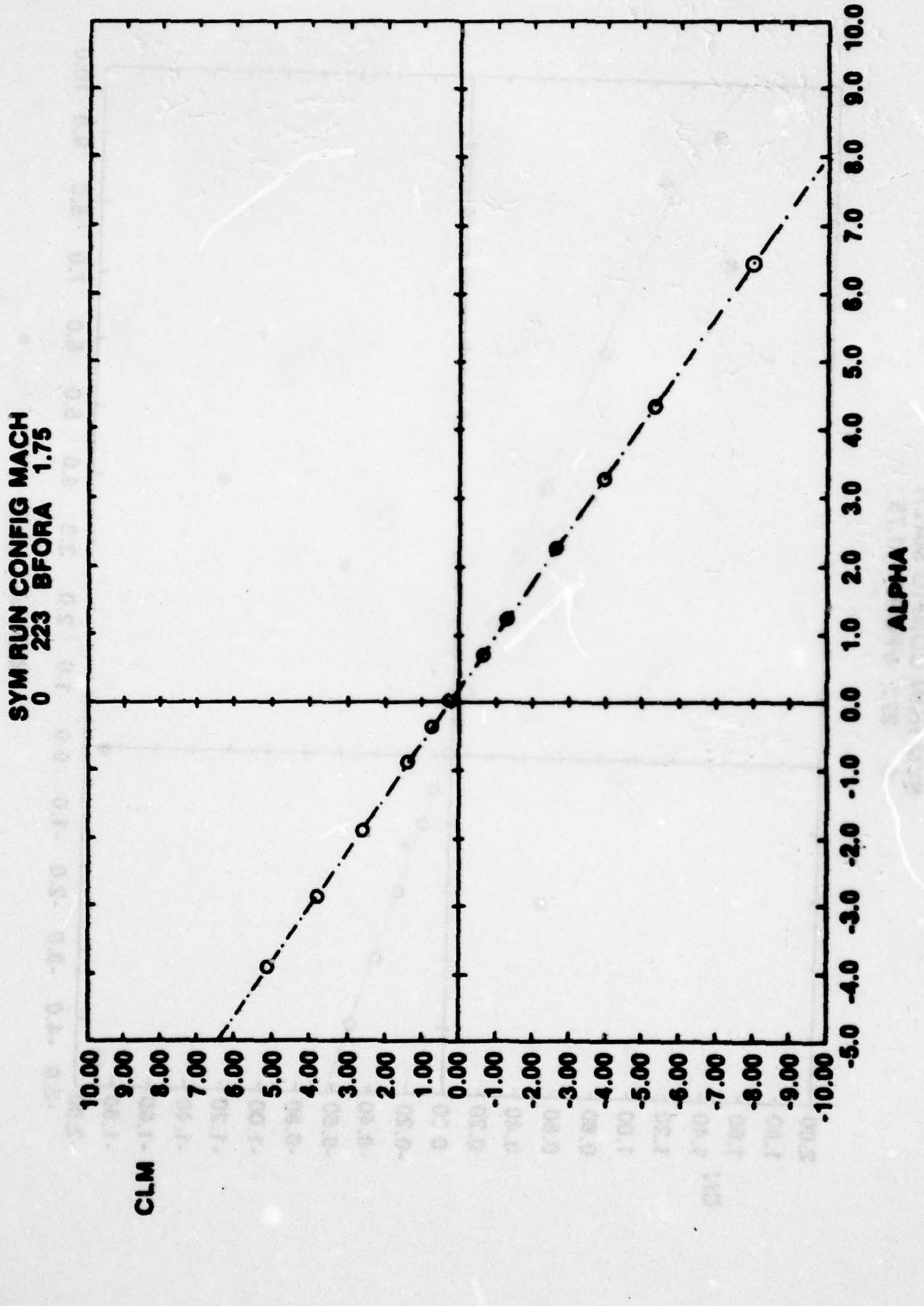

SYM RUN CONFIG MACH
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CLM
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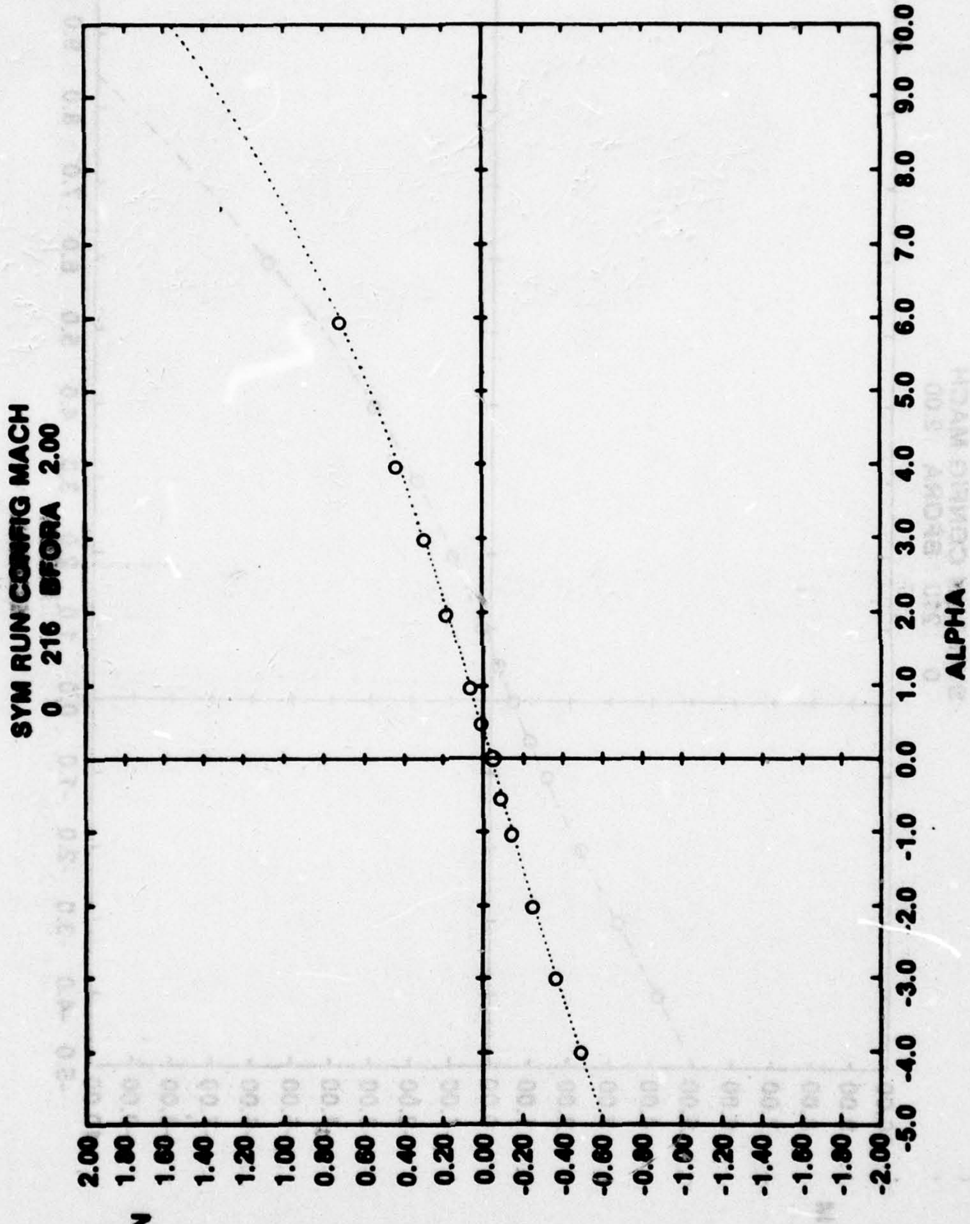
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ALPHA
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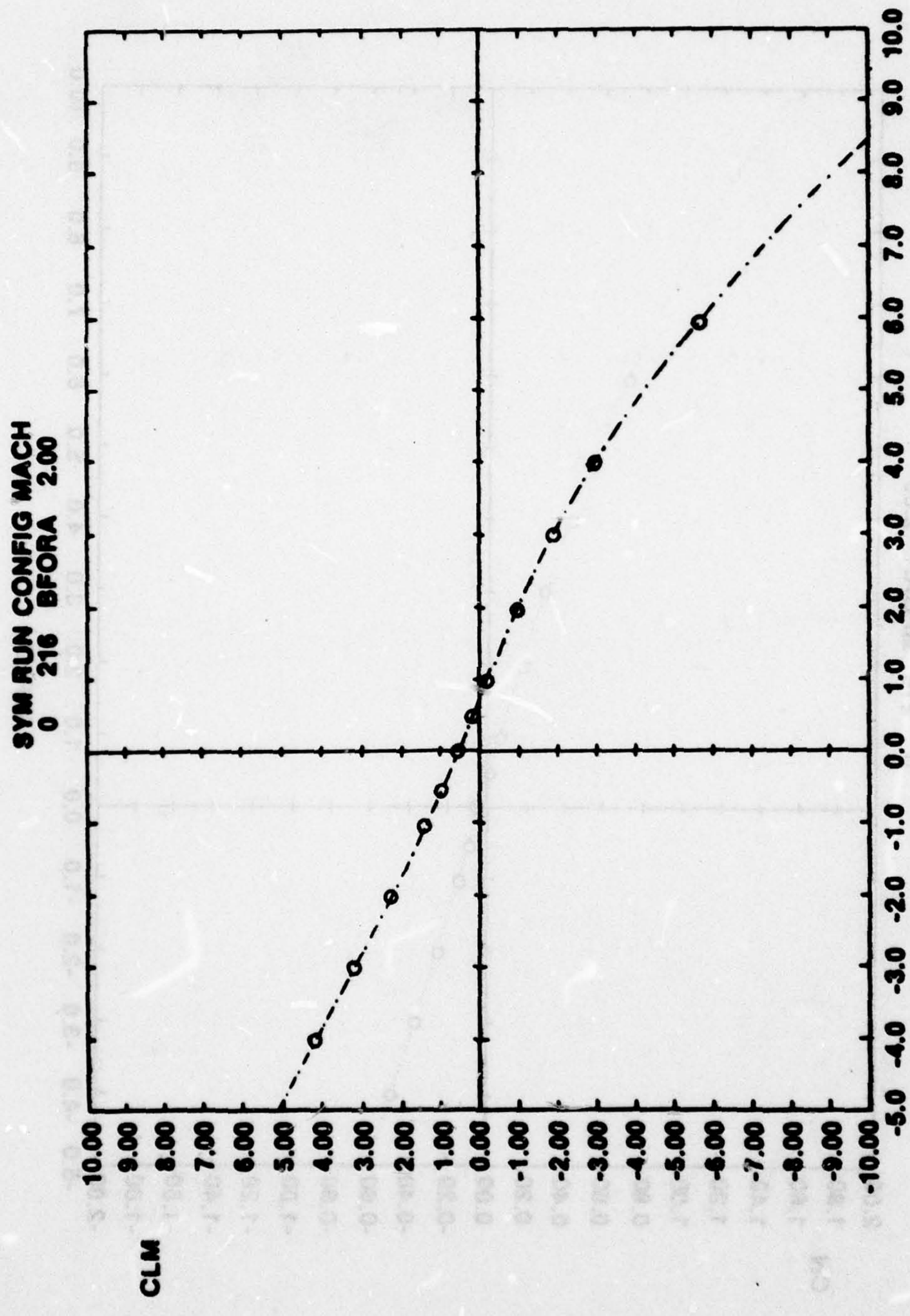
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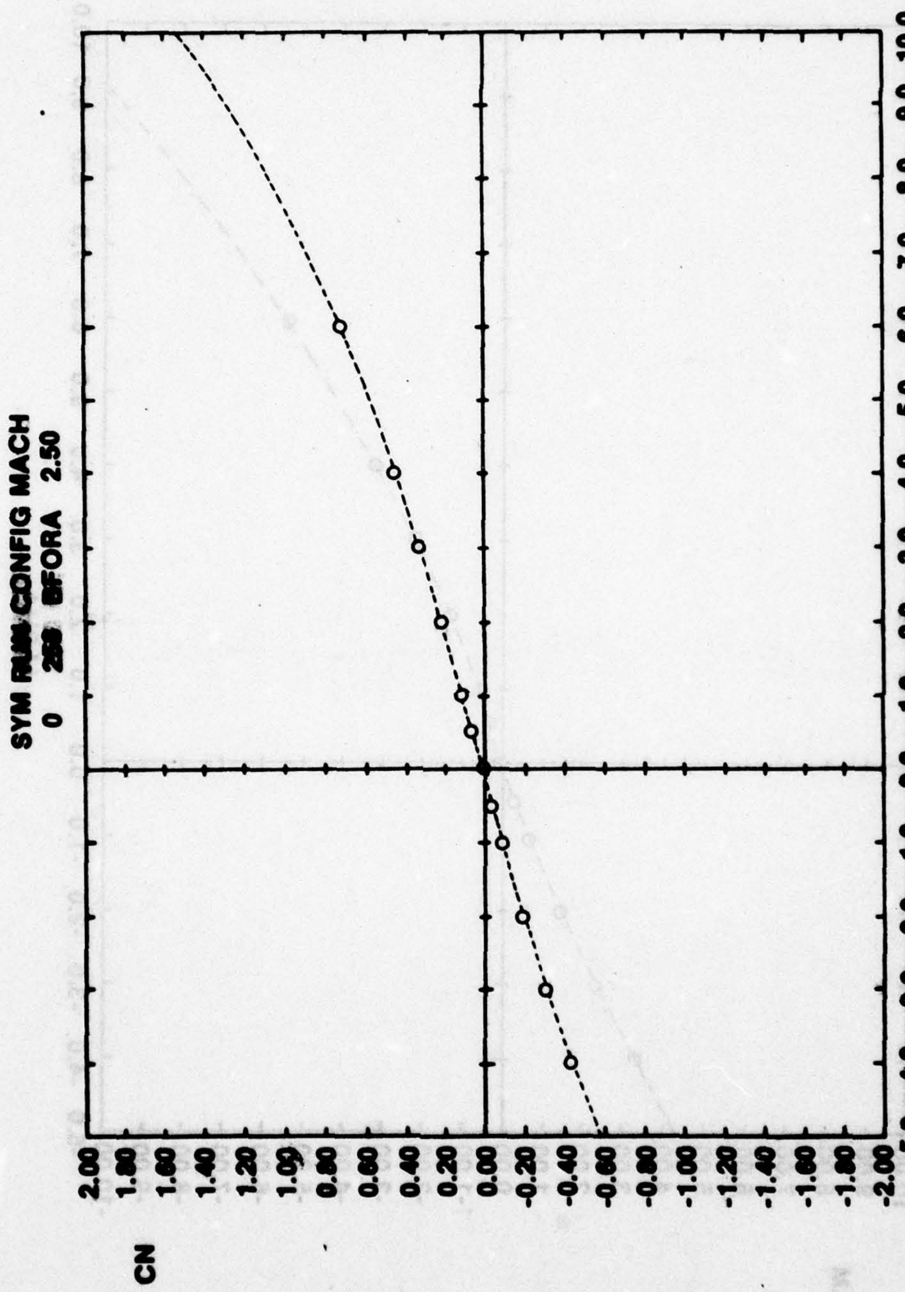
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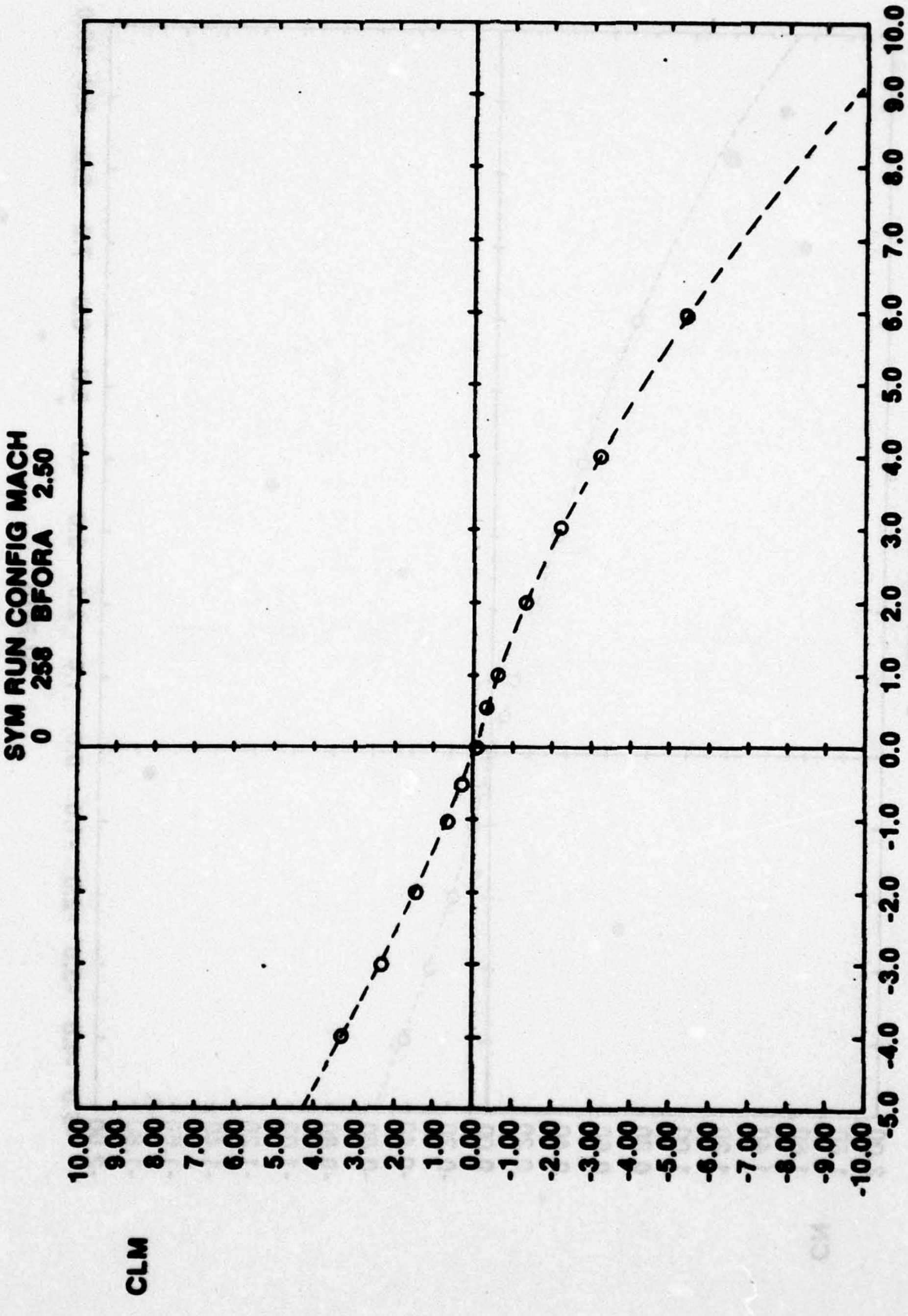
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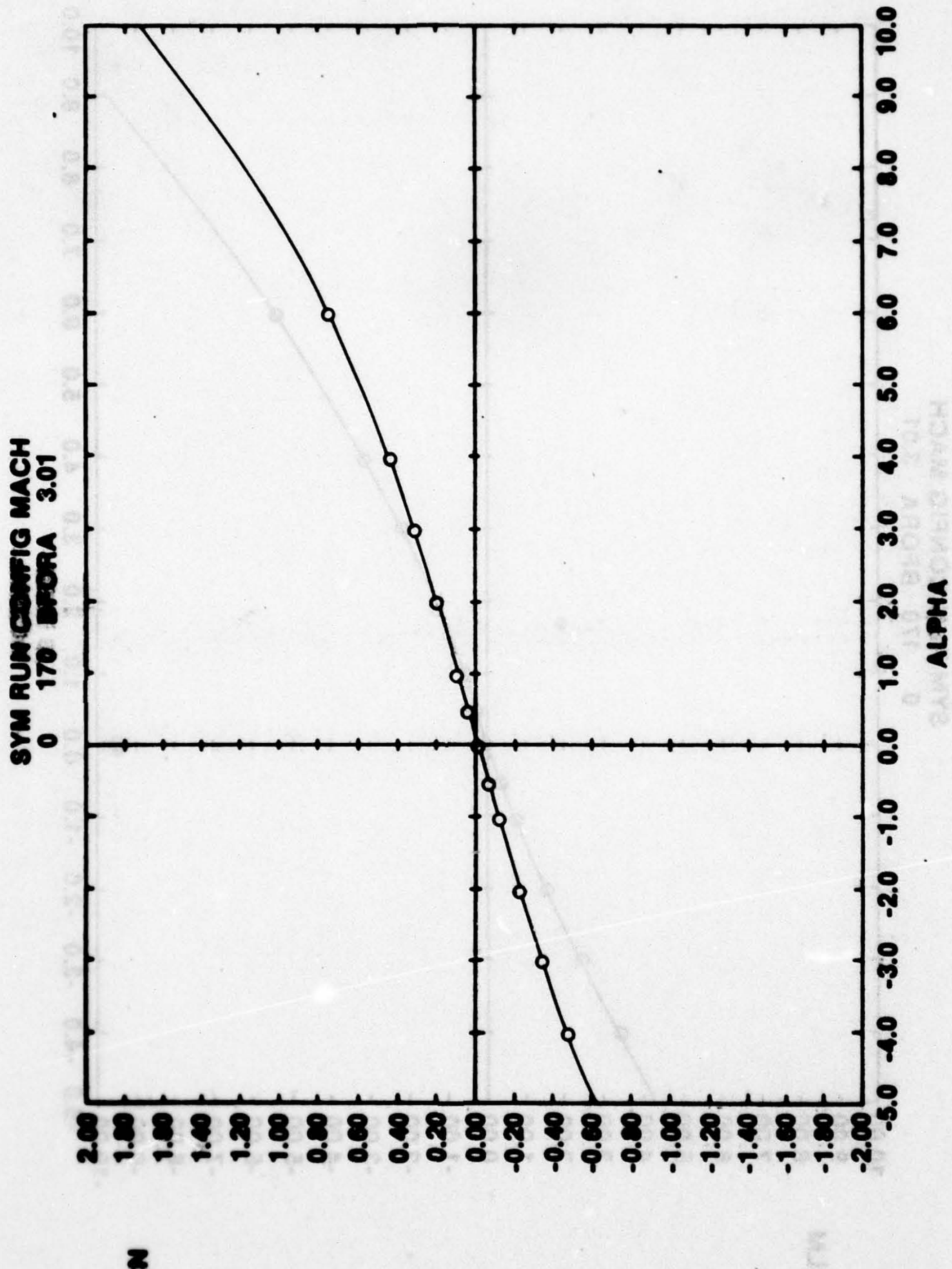

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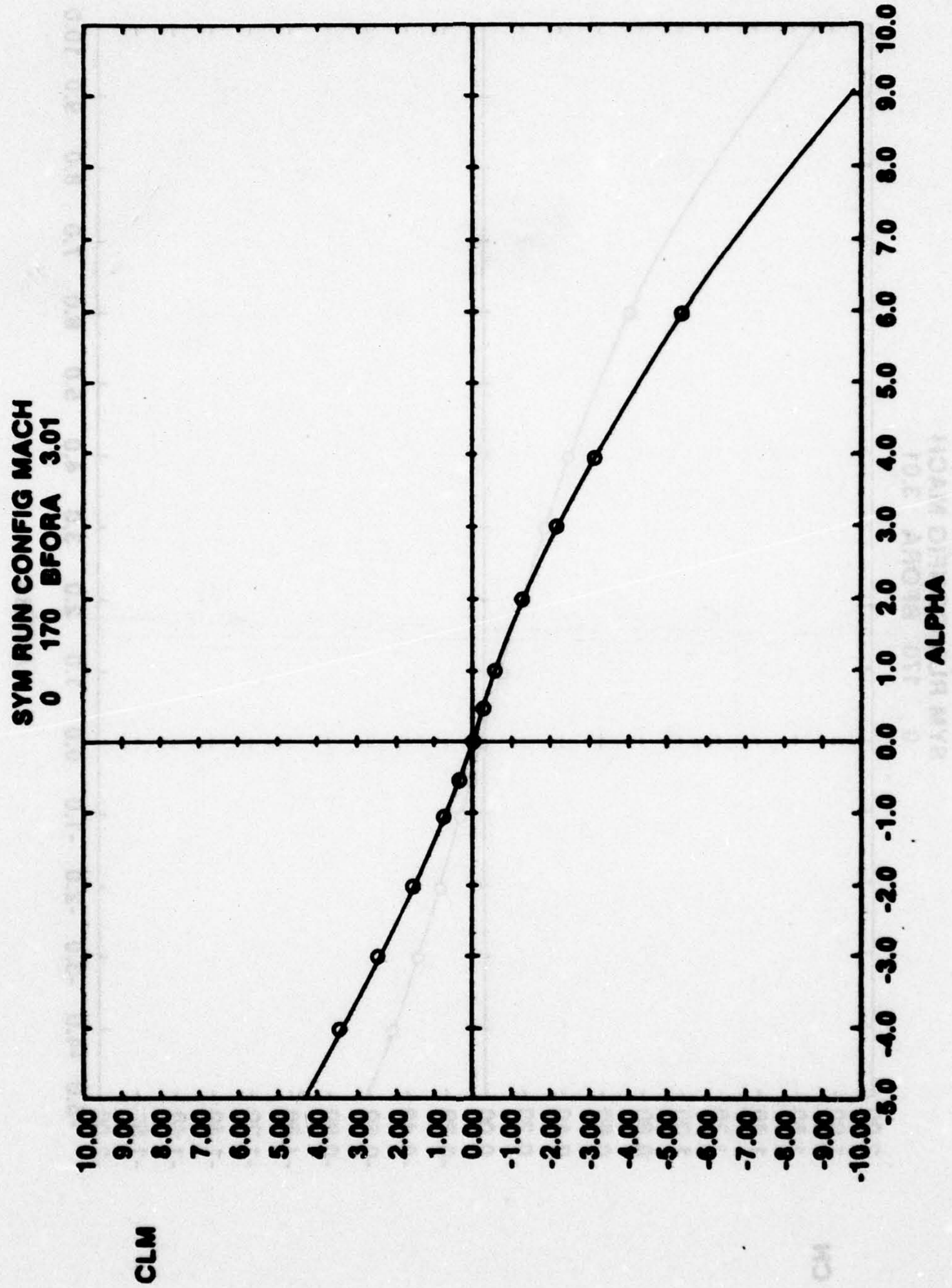

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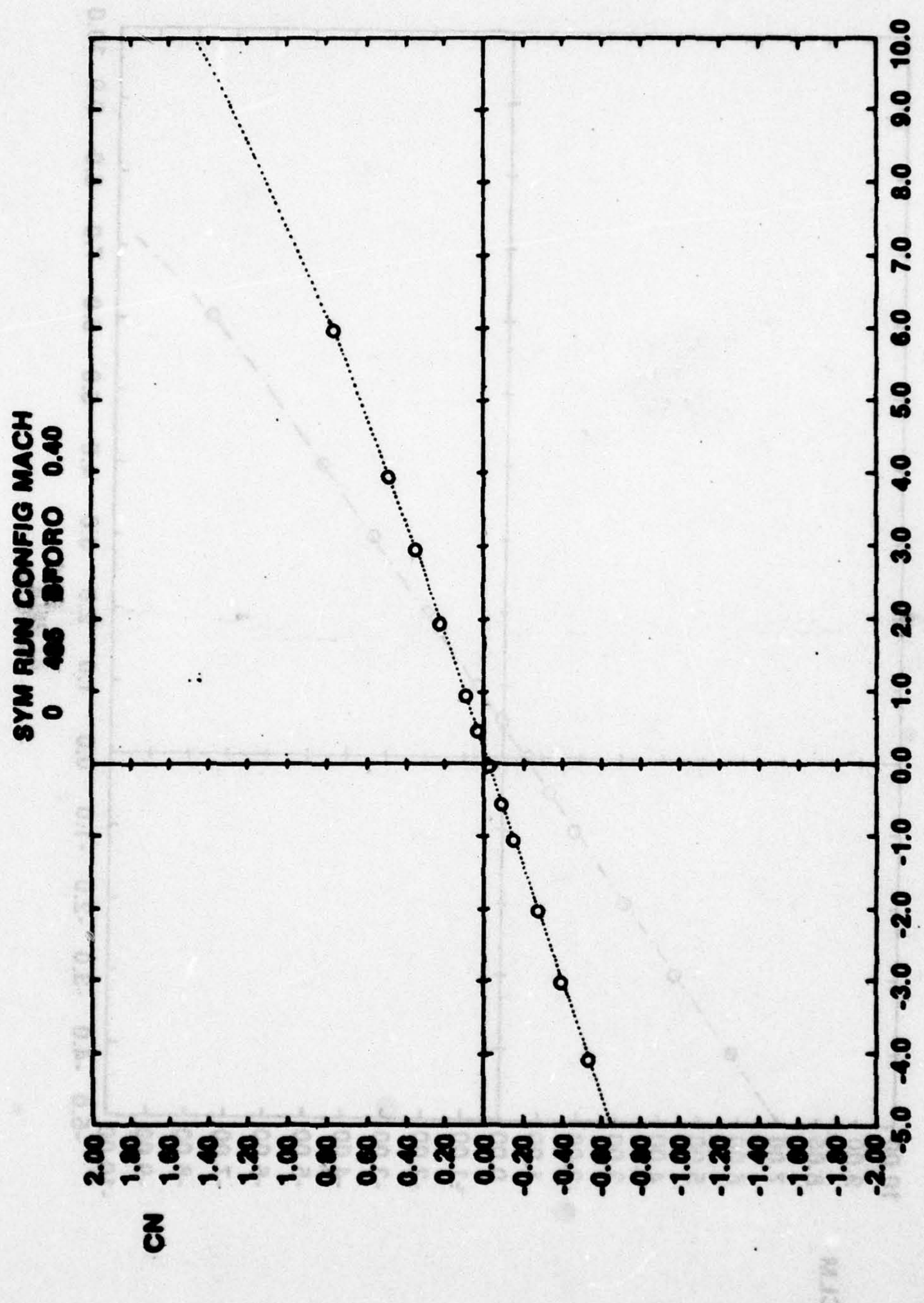
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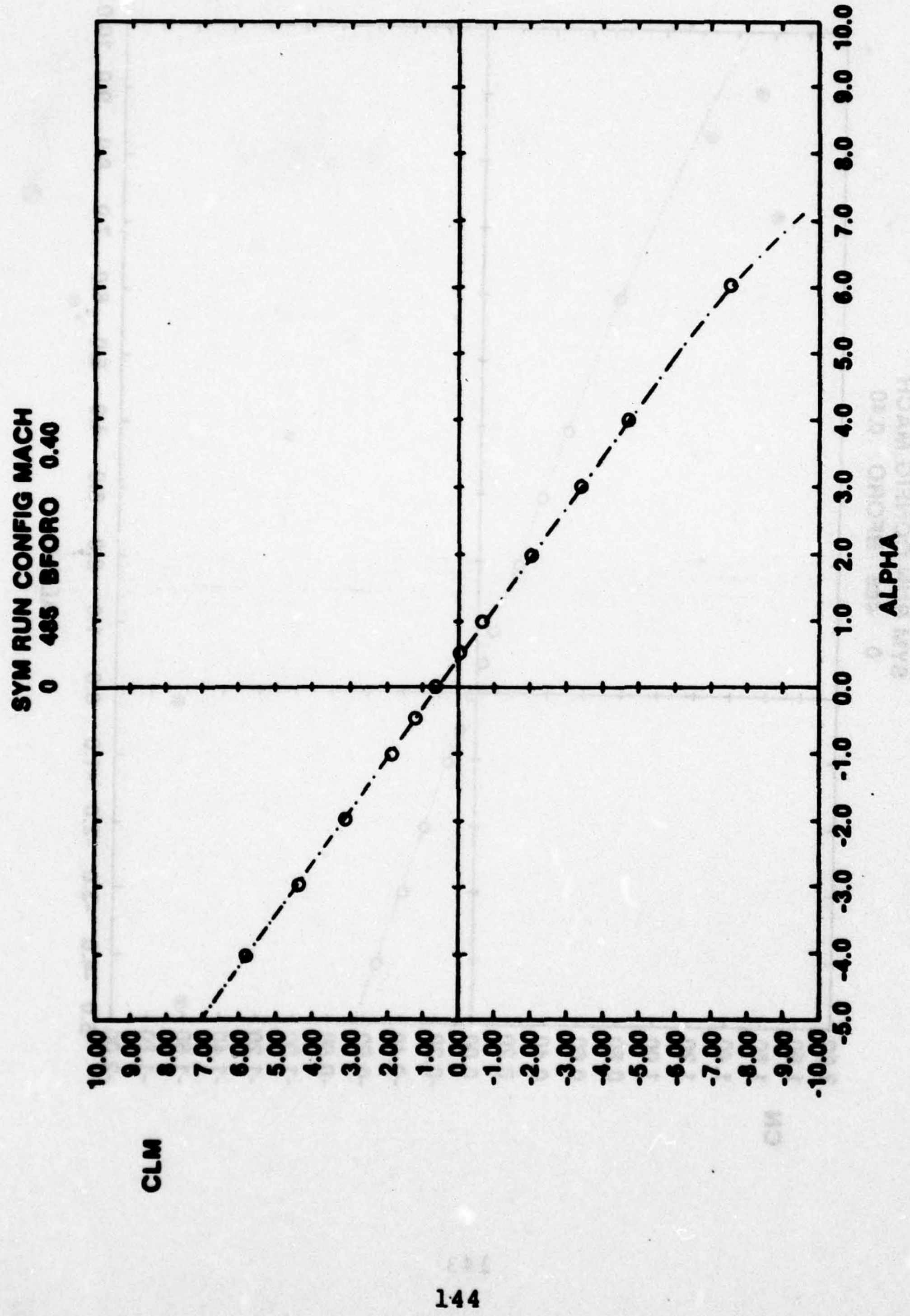
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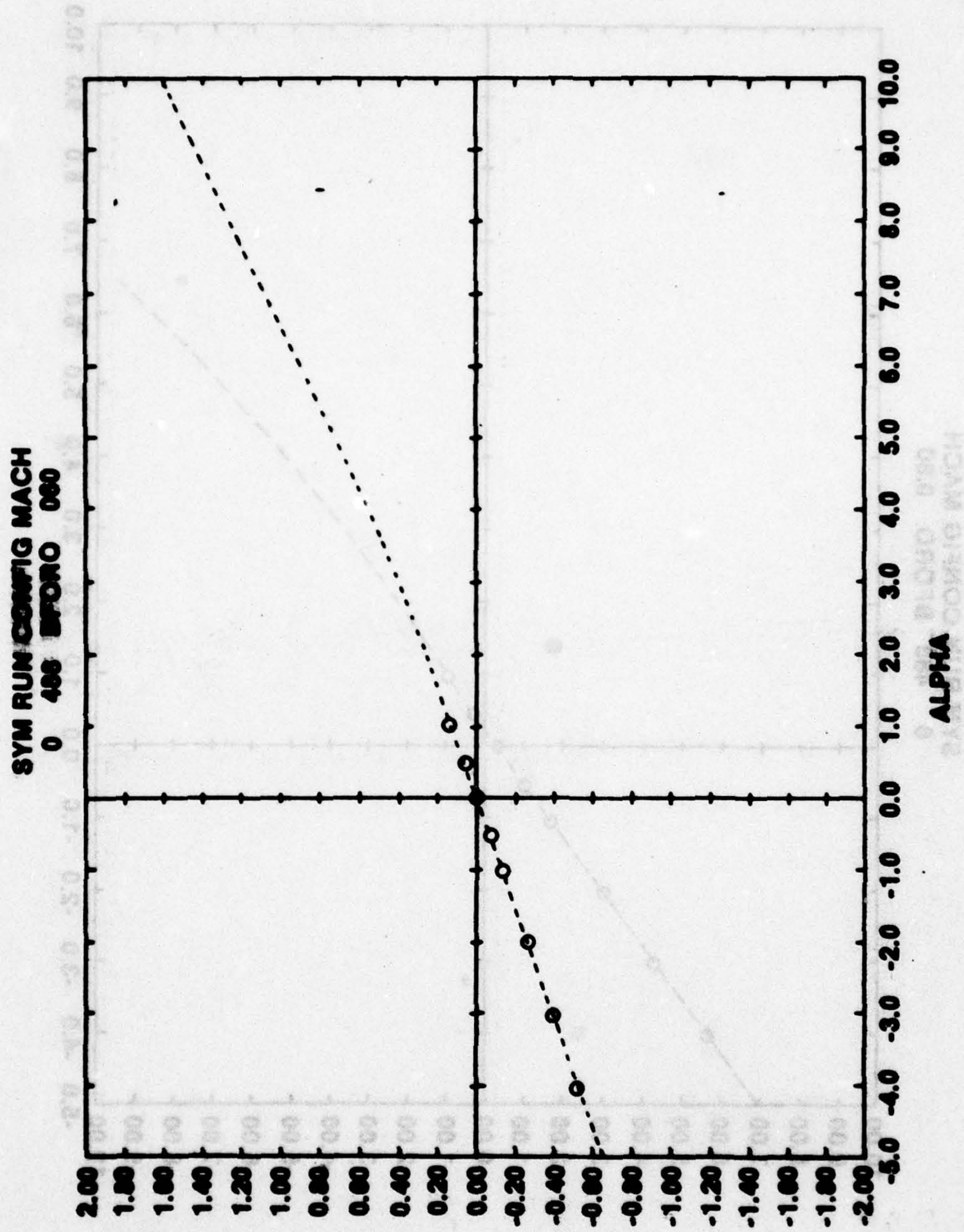
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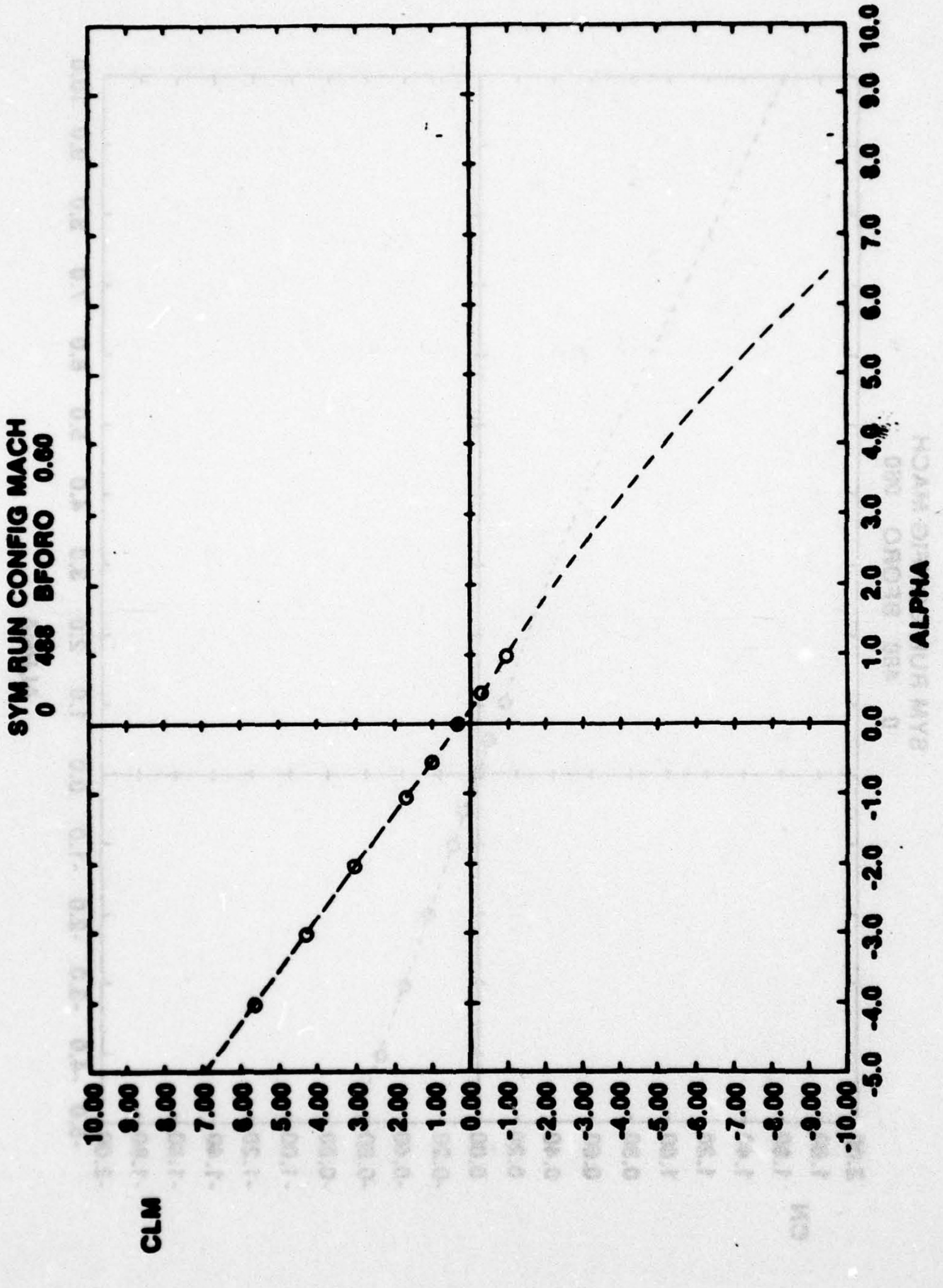
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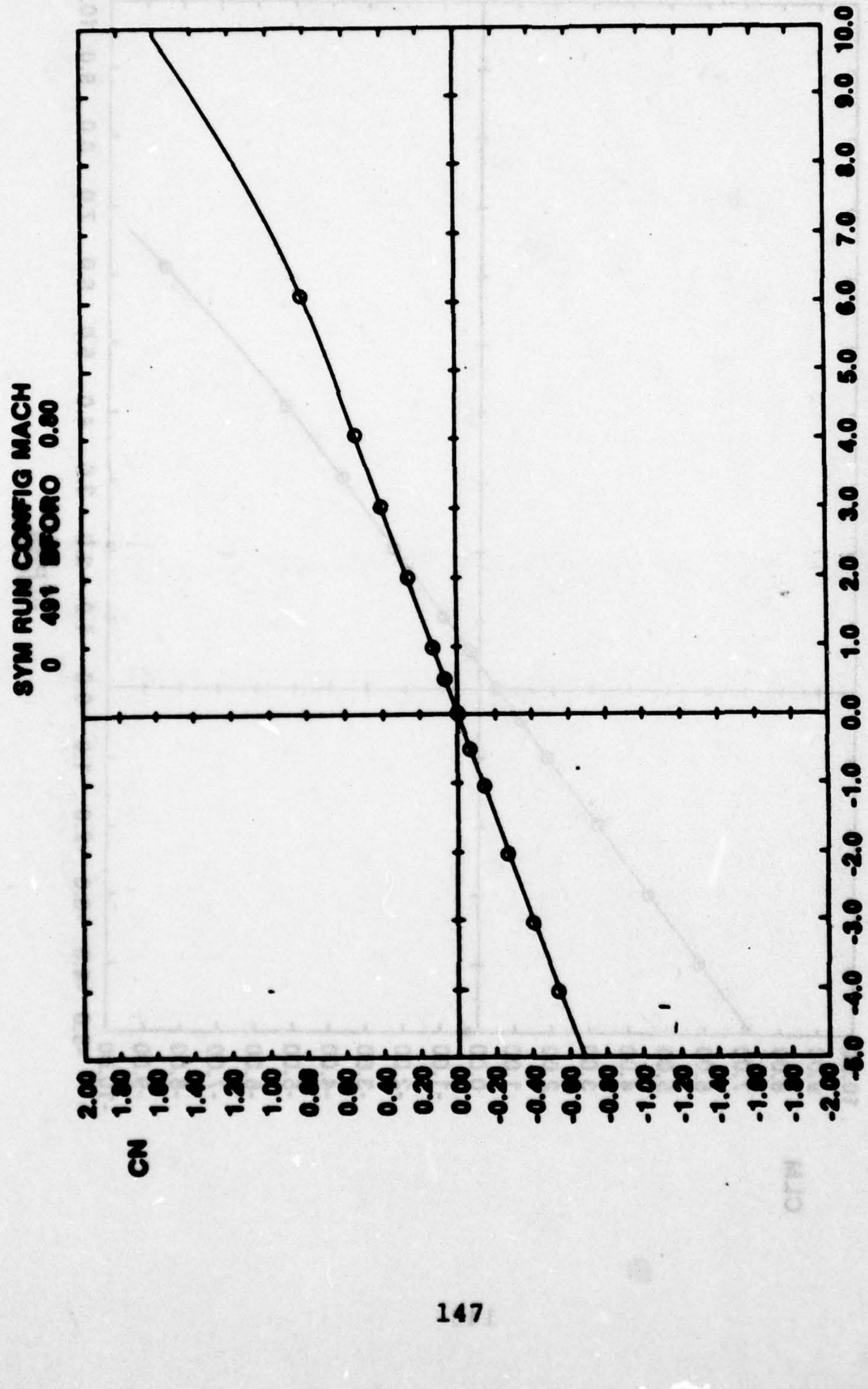
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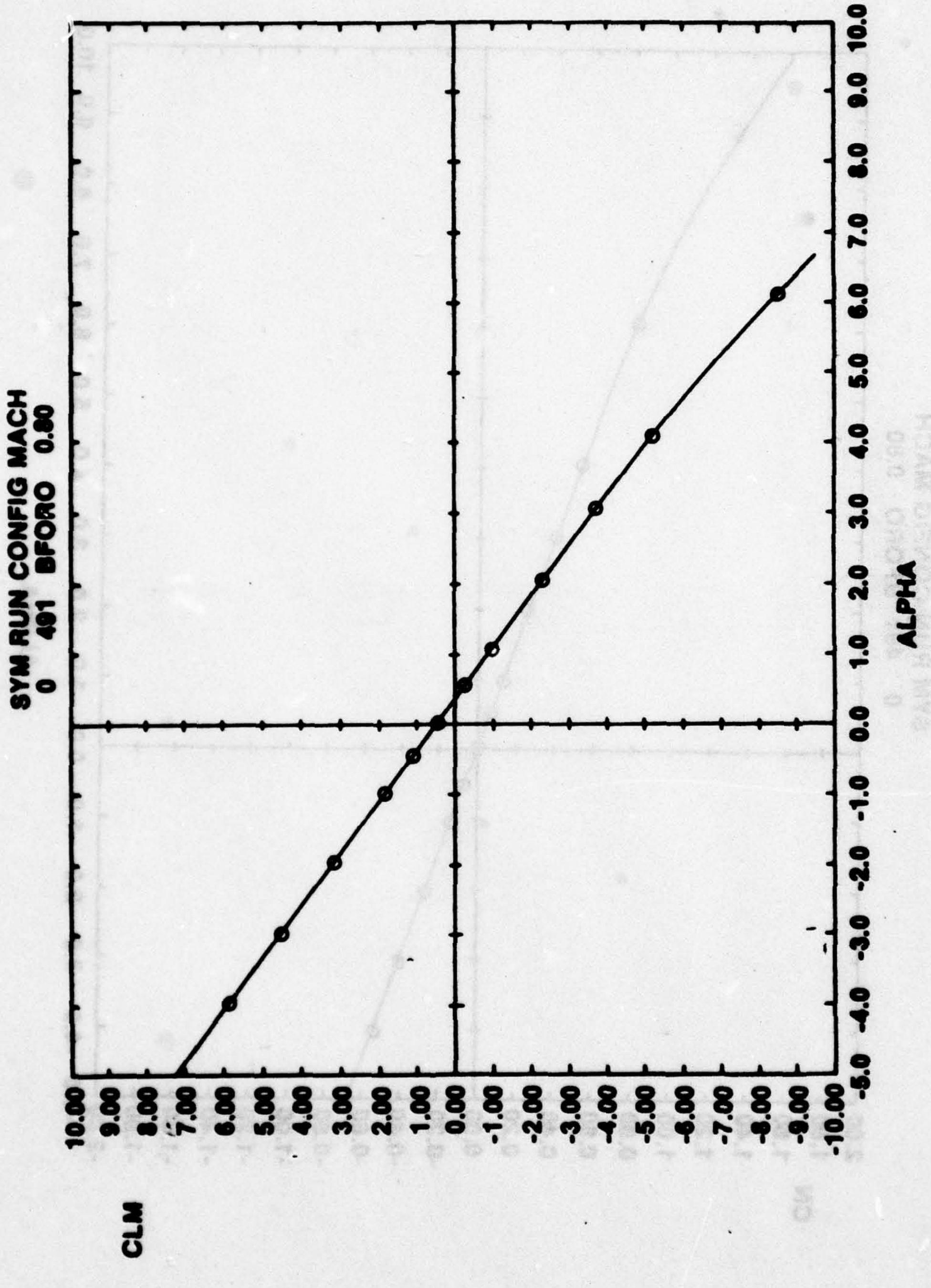
CN
ALPHA



SYM RUN CONFIG MACH
0 491 BFORO 0.80
CLM
ALPHA
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9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
-10.00
-5.0
-4.0
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-2.0
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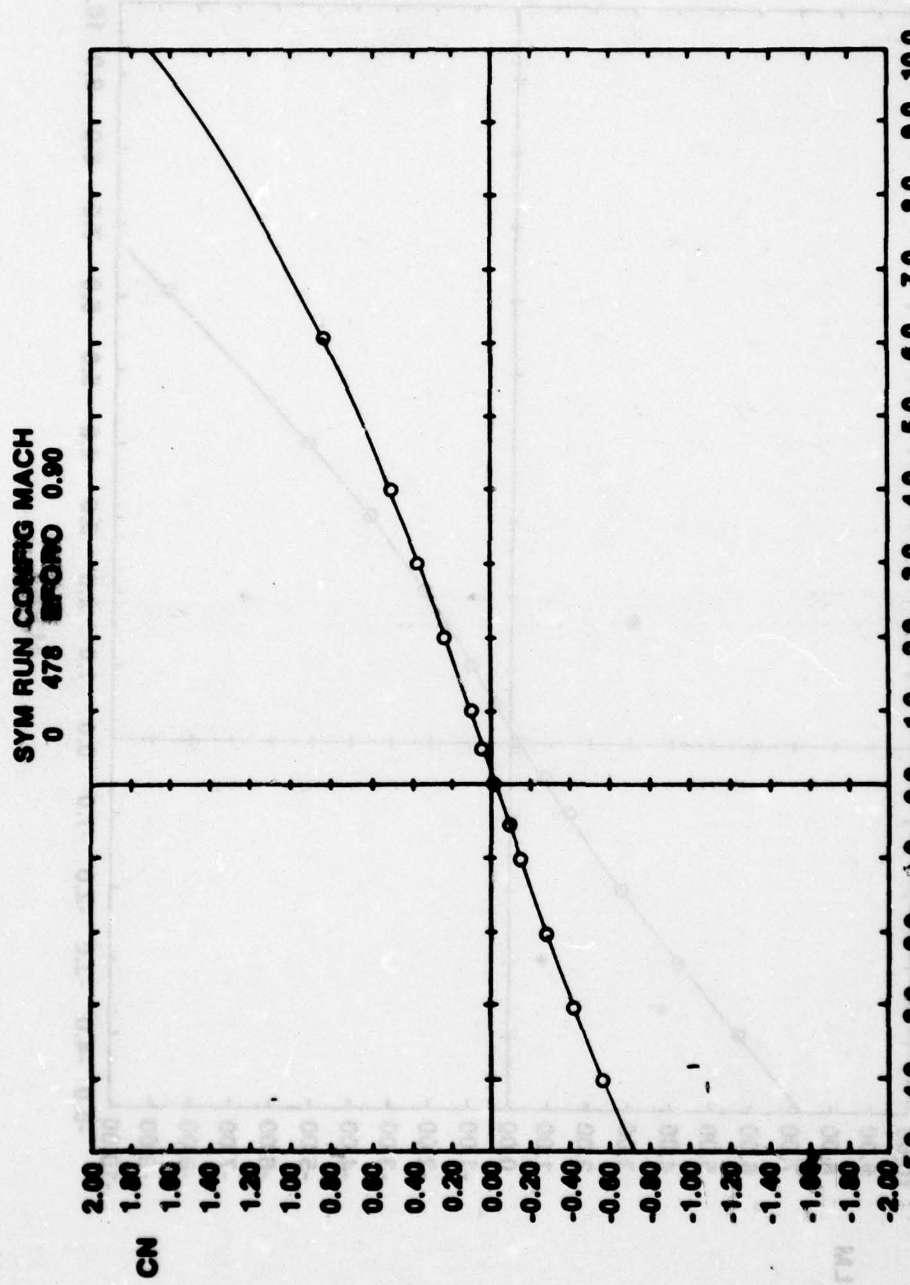
10.0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0.40
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0.00
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-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.80
-2.00
-4.0
-3.0
-2.0
0.0
1.0
2.0
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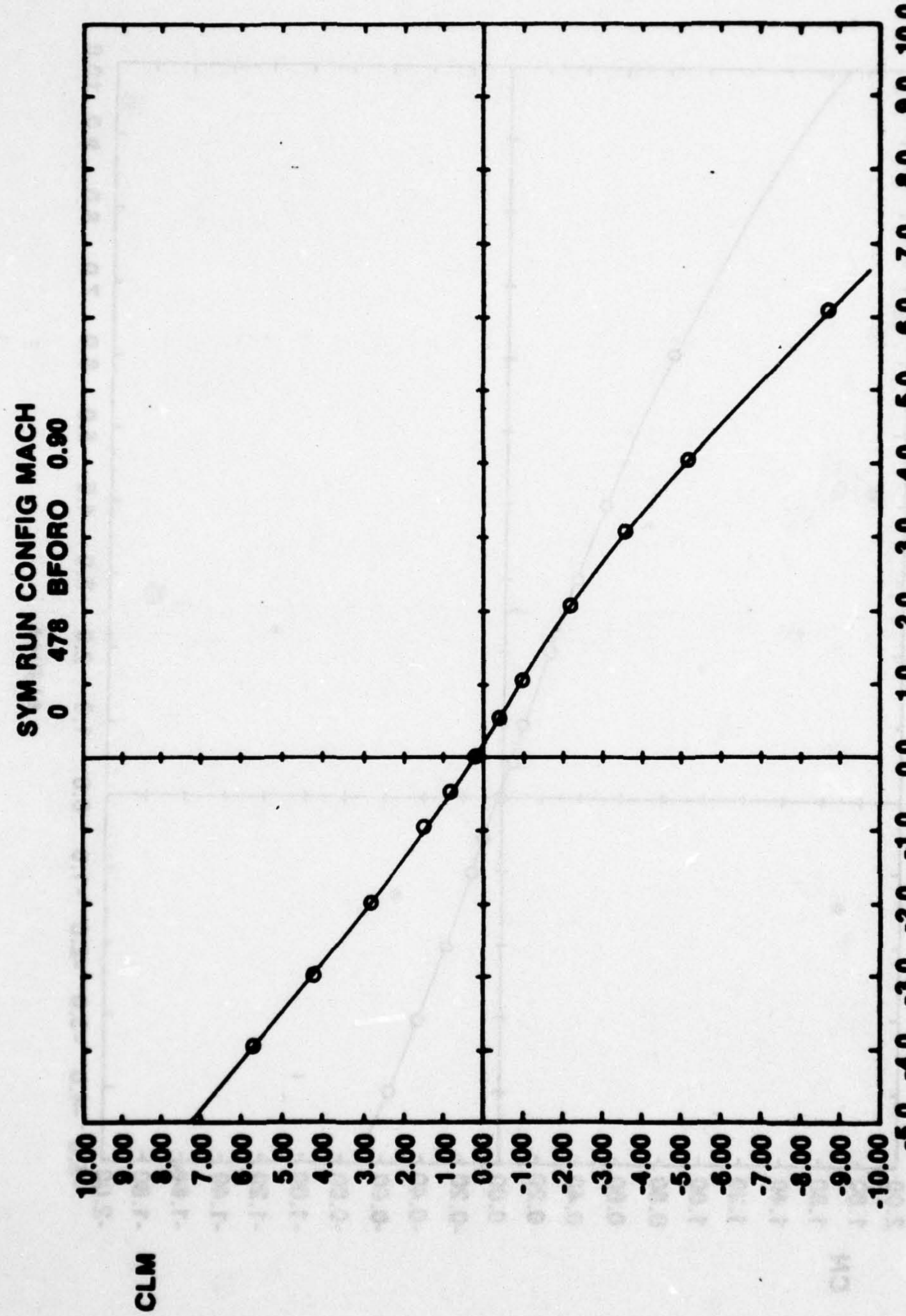
8.0
9.0
10.0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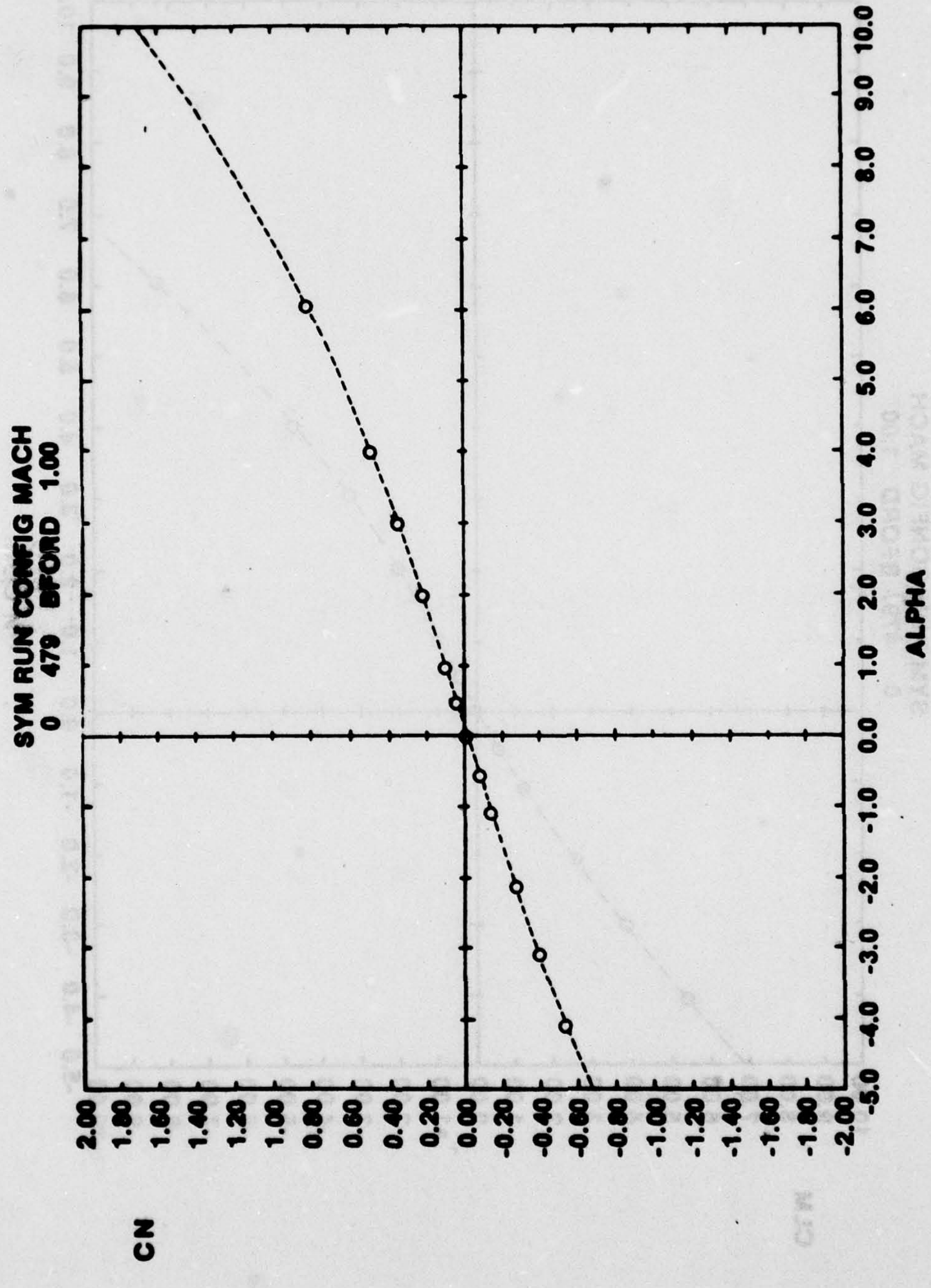
CLM
ALPHA


SYM RUN CONFIG MACH
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CN
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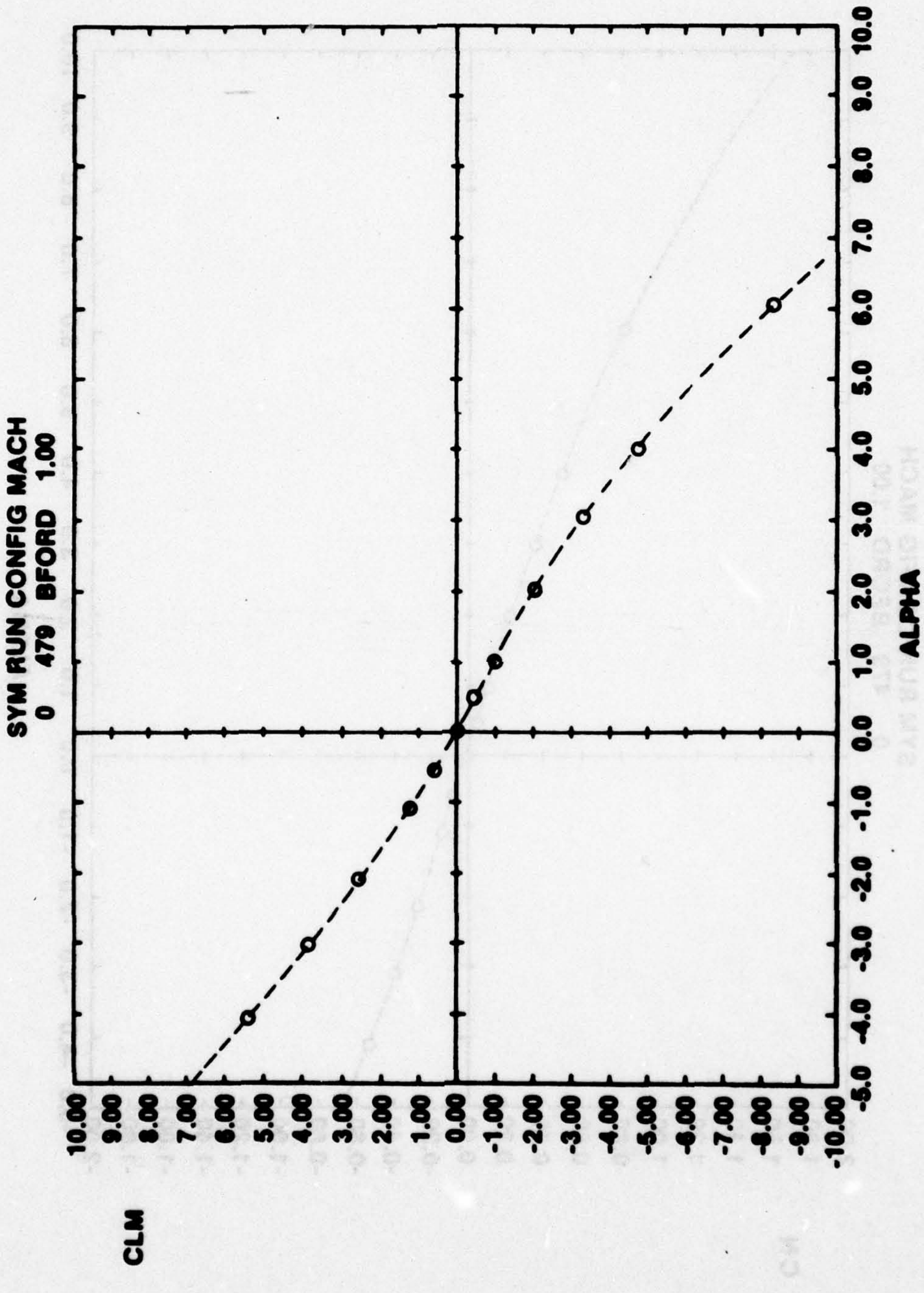
-5.0 -4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
ALPHA



SYM RUN CONFIG MACH
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CLM
ALPHA
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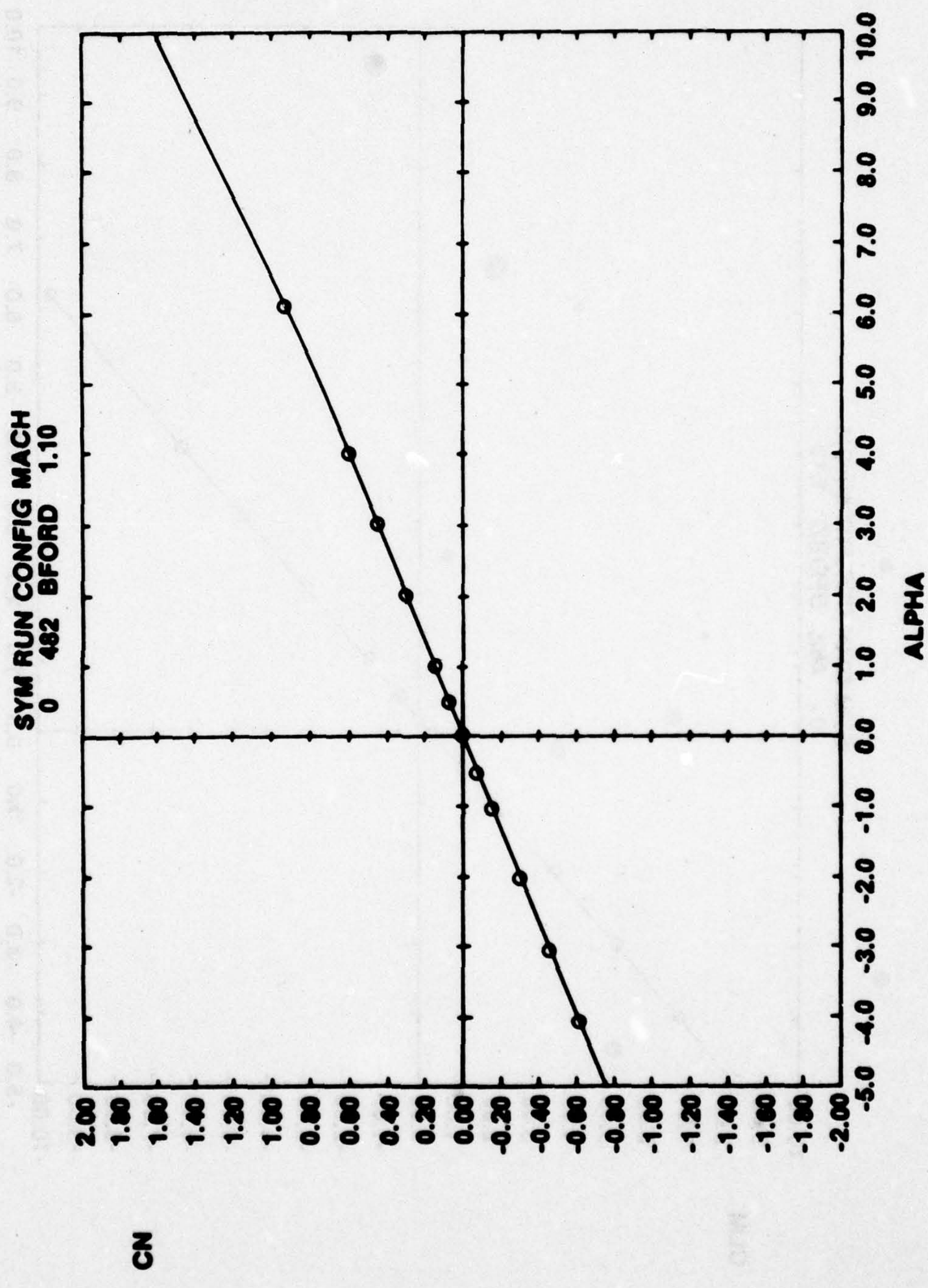
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
-10.00
-5.0
-4.0
-3.0
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0


SYM RUN CONFIG MACH
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CN
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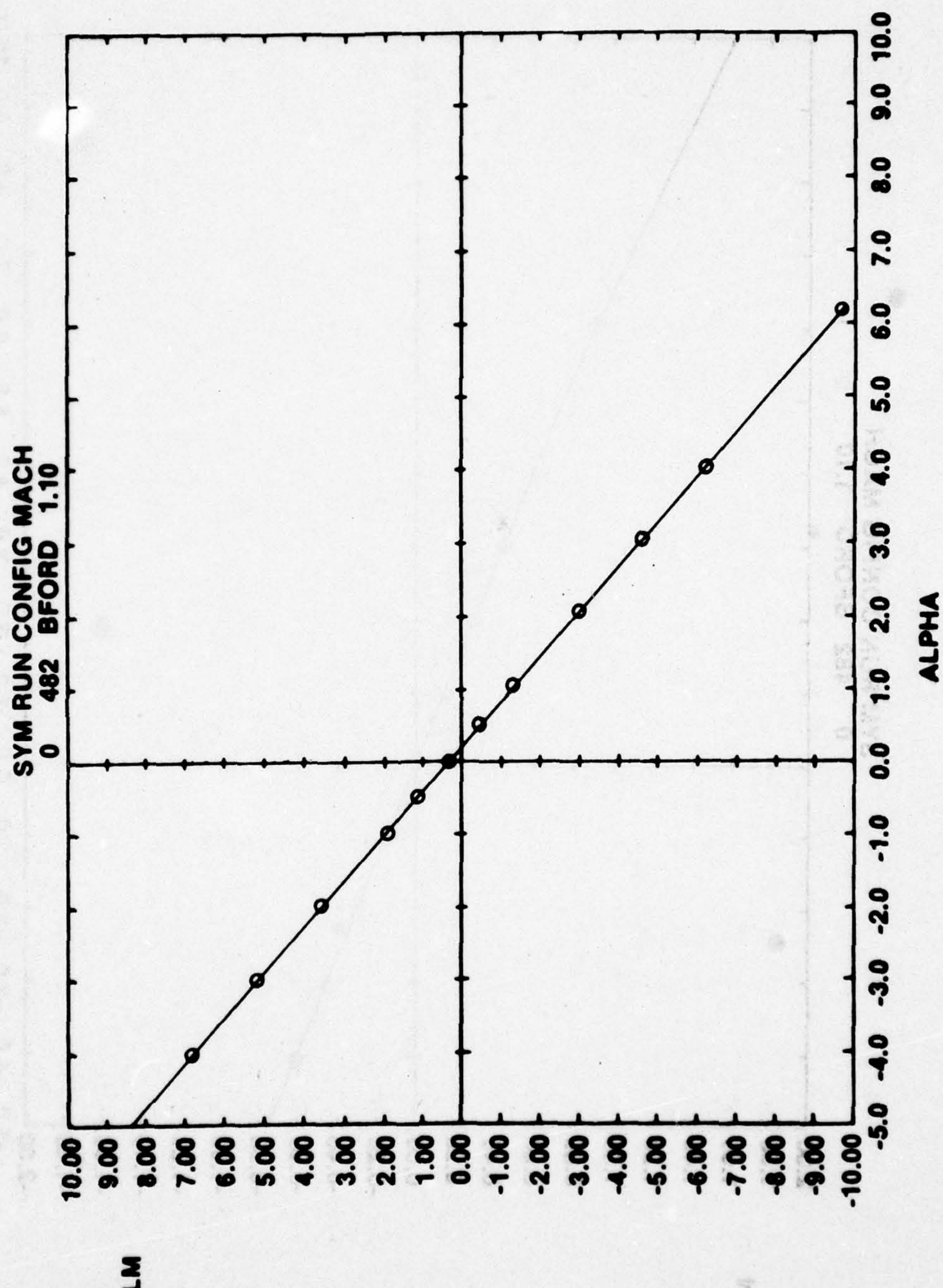
-5.0 -4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
ALPHA


SYM RUN CONFIG MACH
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CLM
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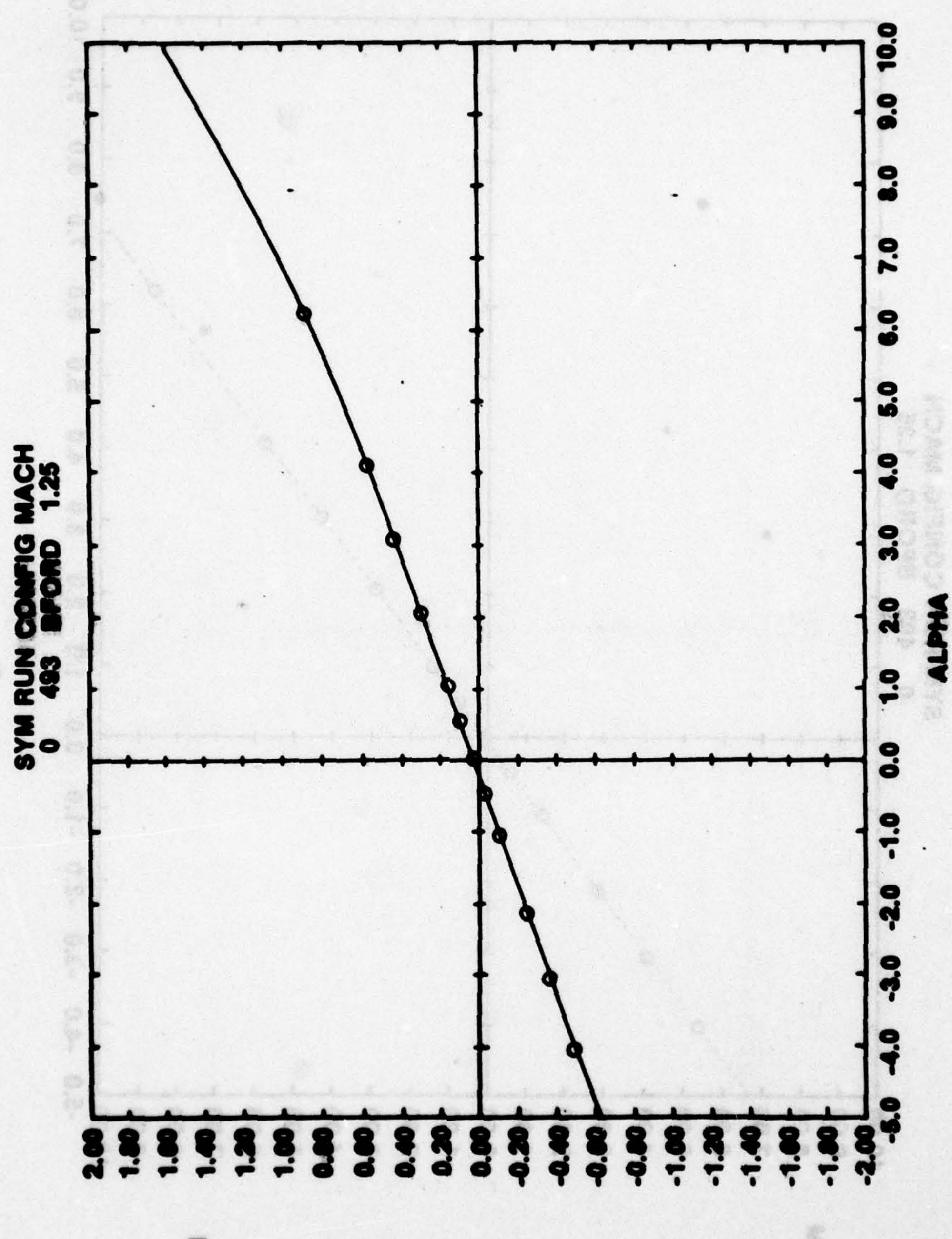
-5.0 -4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
ALPHA


SYM RUN CONFIG MACH
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CN
ALPHA
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1.20
1.00
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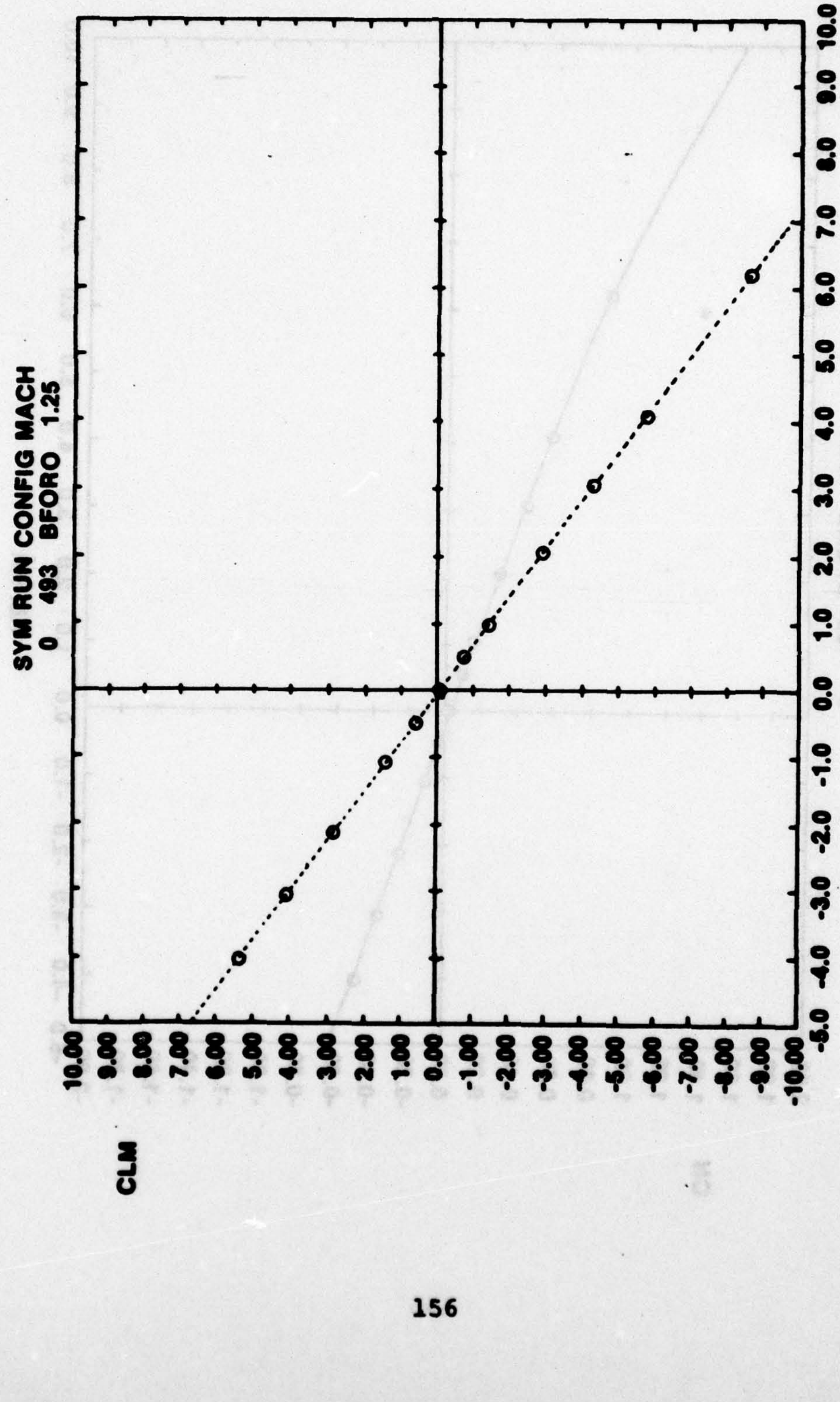
0.60
0.40
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
-1.20
-1.40
-1.60
-1.80
-2.00
-5.0
-4.0
-3.0
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0


SYM RUN CONFIG MACH
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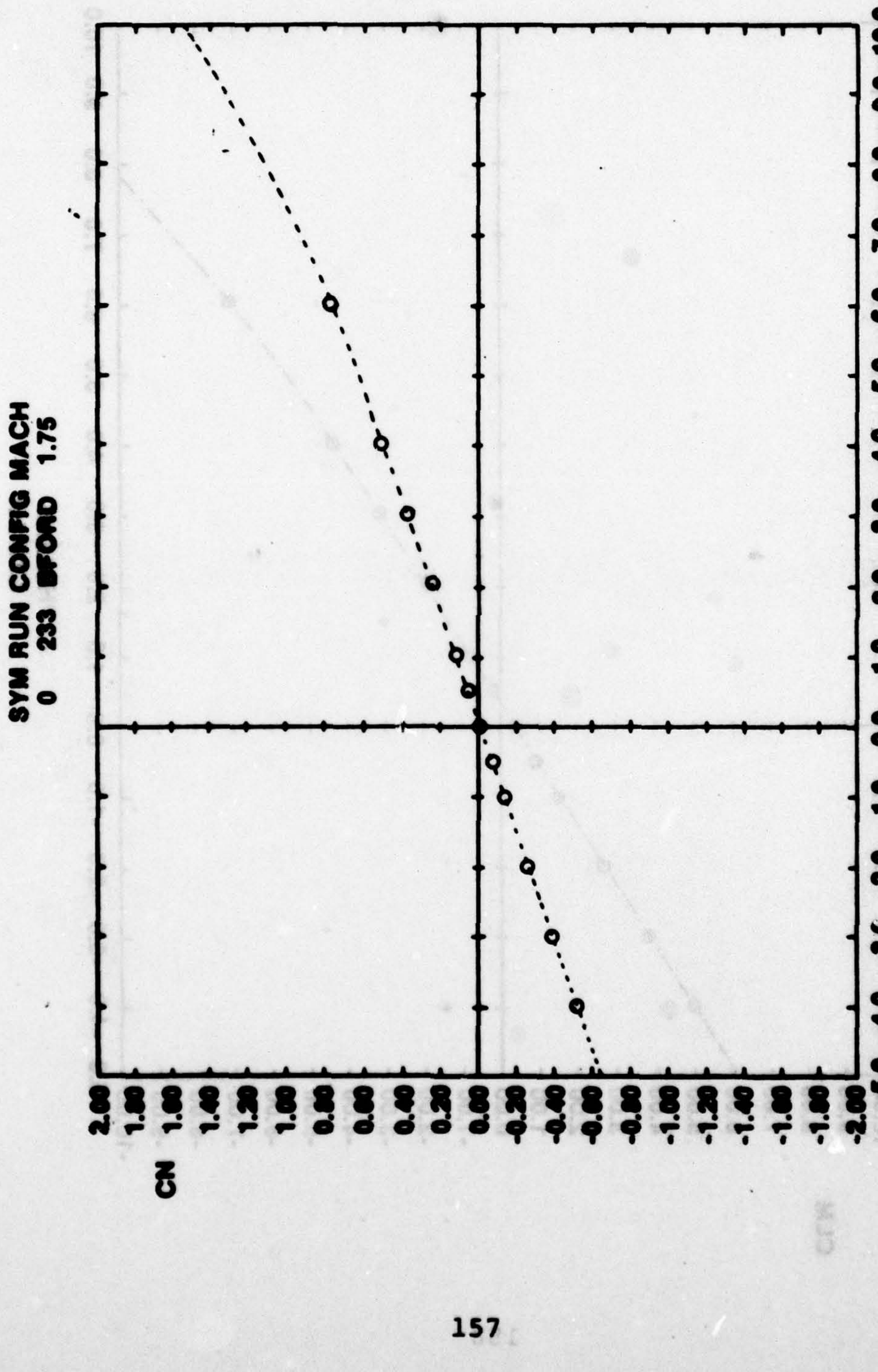
CLM
ALPHA


SYM RUN CONFIG MACH
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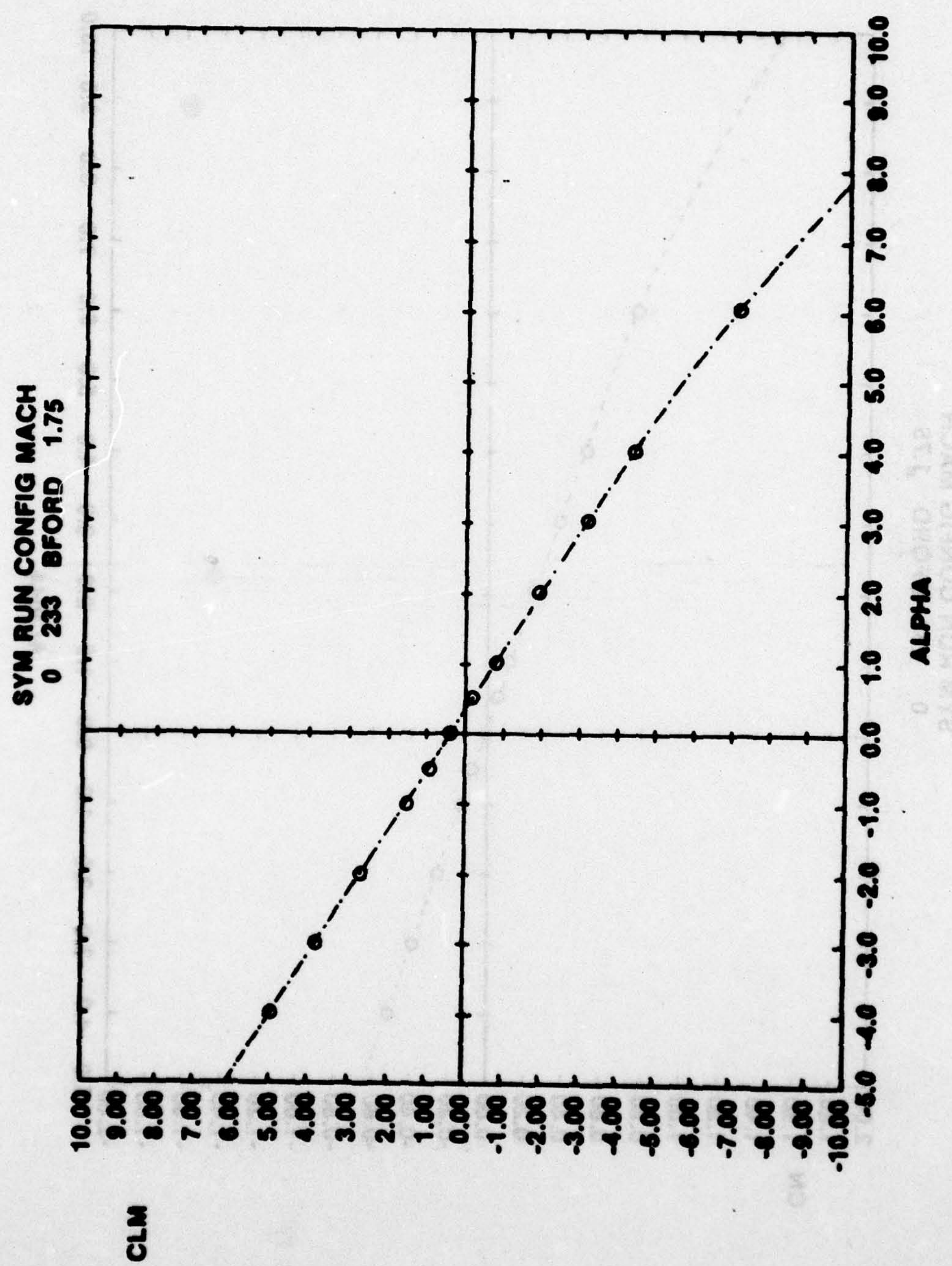
CN
ALPHA


SYM RUN CONFIG MACH
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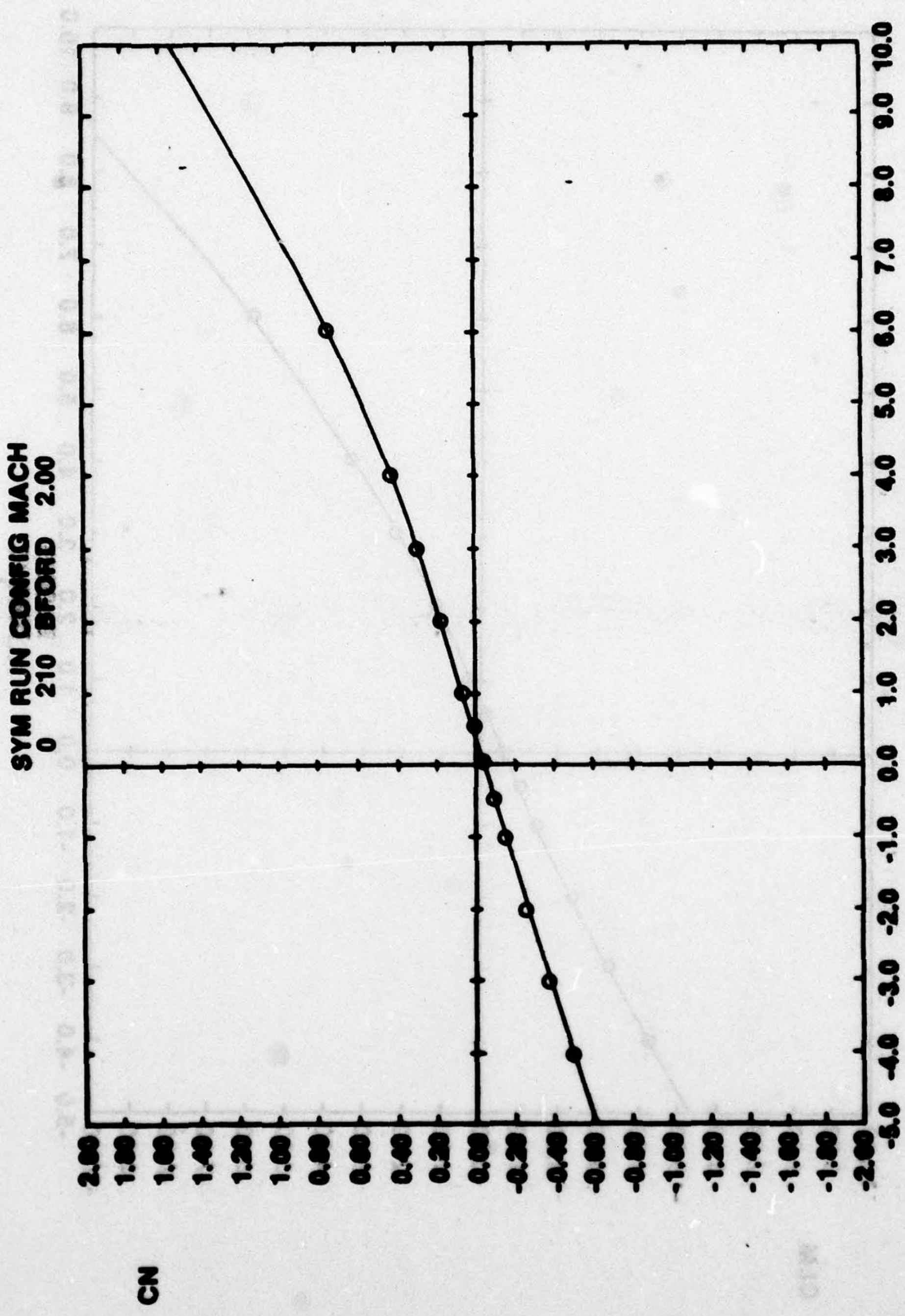
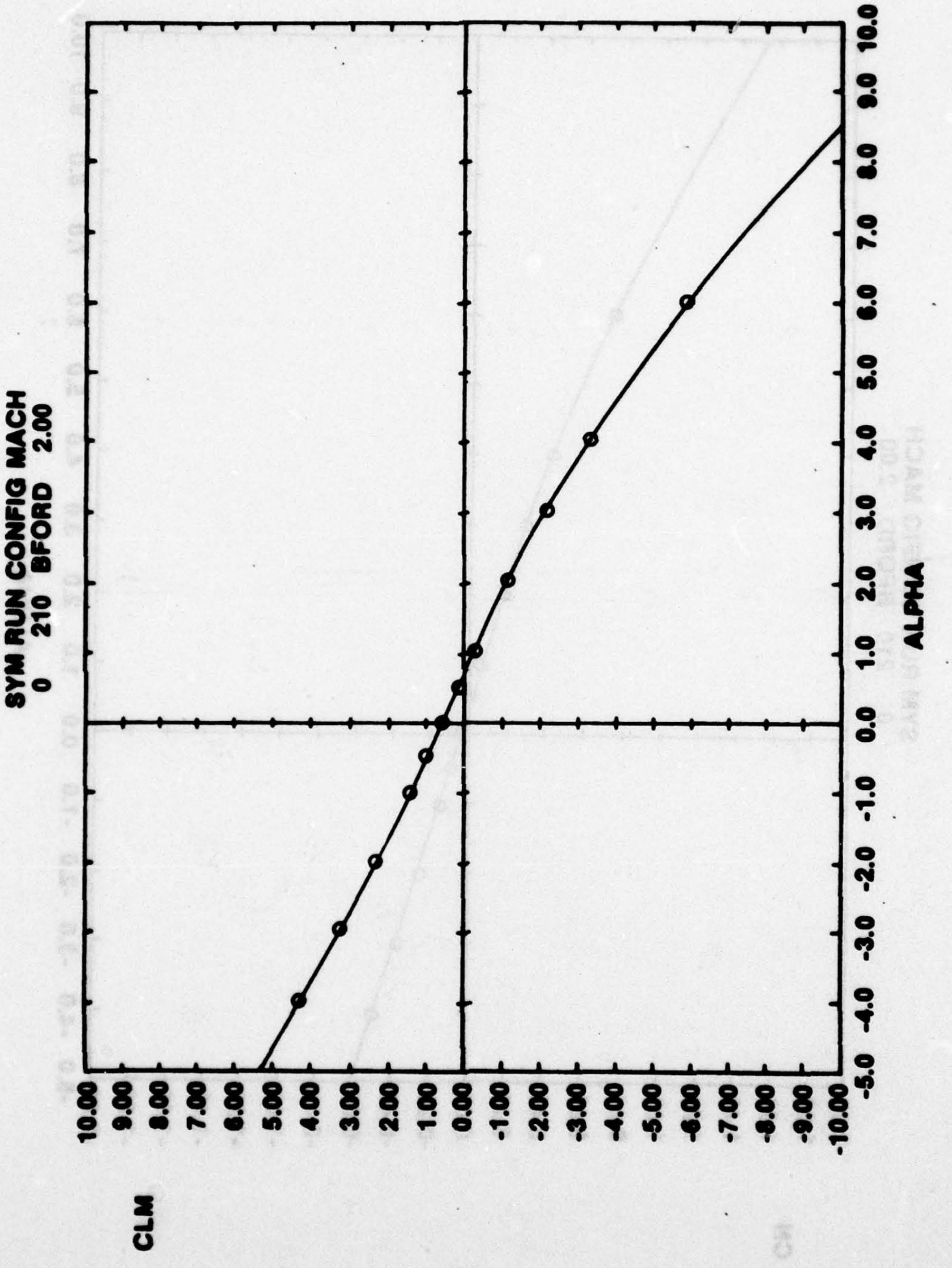
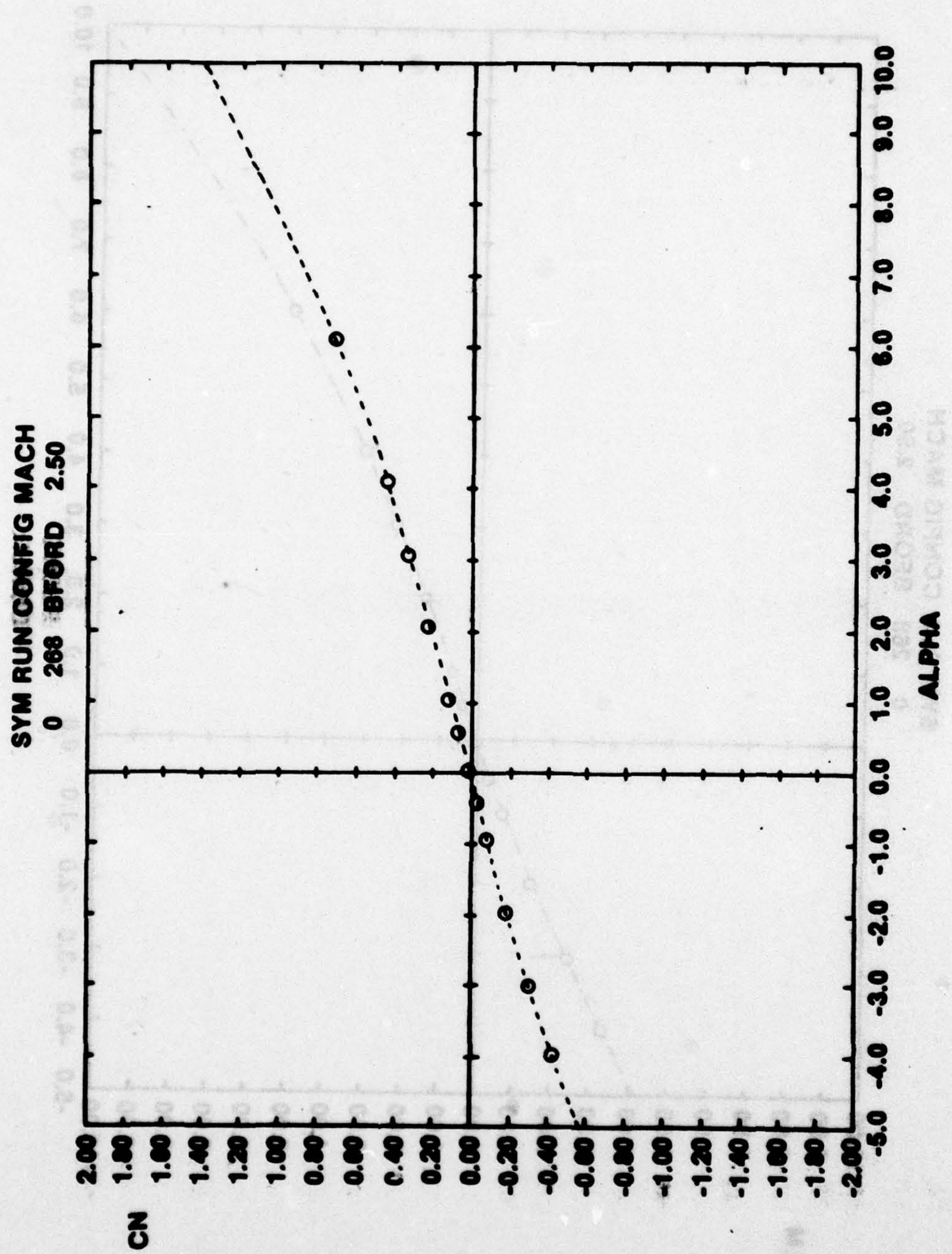
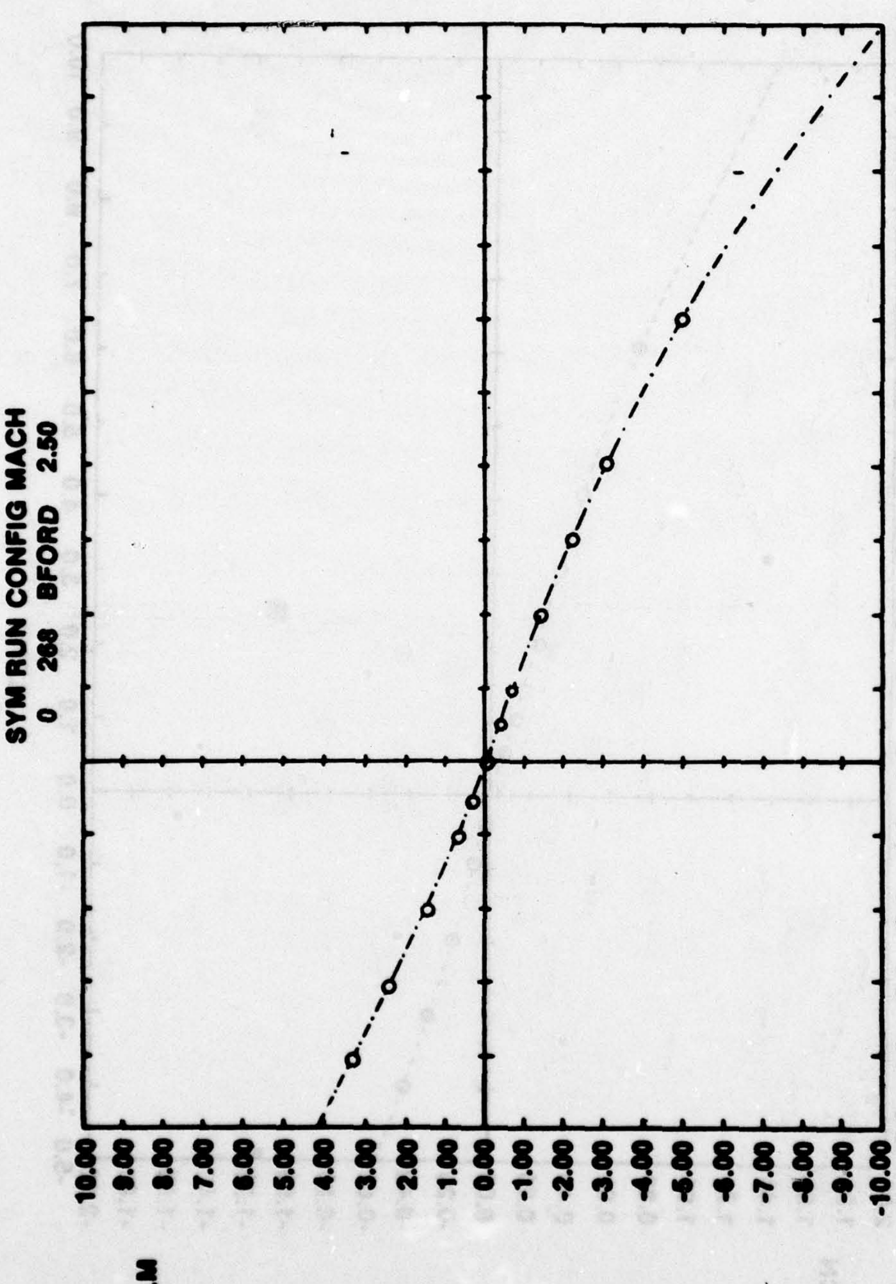
CLM
ALPHA
10.00 9.00 8.00 7.00 6.00 5.00 4.00 3.00 2.00 1.00 0.00 -1.00 -2.00 -3.00 -4.00 -5.00 -6.00 -7.00 -8.00 -9.00 -10.00
-5.0 -4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0


SYM RUN CONFIG MACH
0 210 BFORD 2.00
CN
2.00 1.80 1.60 1.40 1.20 1.00 0.80 0.60 0.40 0.20 0.00 -0.20 -0.40 -0.60 -0.80 -1.00 -1.20 -1.40 -1.60 -1.80 -2.00
-5.0 -4.0 -3.0 -2.0 -1.0 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0
ALPHA



SYM RUN CONFIG MACH
0 210 BFORD 2.00
CLM
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
-5.00
-6.00
-7.00
-8.00
-9.00
-10.00
ALPHA
-5.0
-4.0
-3.0
-2.0
-1.0
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0


SYM RUN CONFIG MACH
0 268 BFORD 2.50
CN
ALPHA


SYM RUN CONFIG MACH
0 268 BFORD 2.50
CLM
ALPHA
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
-3.00
-4.00
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0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0

Appendix B

Run Log

DATE SET SUMMARY DISC RDKA02

TEST FACILITY AEDC 4T TEST DATE MAY 1978 TEST I.D. P41C-11

DATA SET	CONFIGURATION	A	P	M	DATA SET POSITION/CRT 1 .01	2 1	3 2.5	4 4	5 6	6 7.2	7 8	8 10	9 12	10 15	11 20	12 37.5
B60001	BFFRA	B	0	.4	314	313		312				311				310
B60002	BFFRA	B	0	.6	317					316		315				
B60003	BFFRA	B	0	.8	318					319		320				
B60004	BFFRA	B	0	.9	325			324	323	322			321			
B60005	BFFRA	B	0	1	326		327	328		330			331			
B60006	BFFRA	B	0	1.1	335		334		333	332						
B60007	BFFRA	B	0	1.25	336	337	339	340								
B60008	BFORA	B	0	.4	356	359		360				361				362
B60009	BFORA	B	0	.6	366					365		364				
B60010	BFORA	B	0	.8	367					368		369				
B60011	BFORA	B	0	.9	376			375	374	373			372			
B60012	BFORA	B	0	1	379		380	381		382			383			
B60013	BFORA	B	0	1.1	388		387		386	385						
B60014	BFORA	B	0	1.25	389	390	391	392								
B60015	B3FORA	-1	D	.6	397						400			403		
B60016	B3FORA	1	D	.6	398						401			404		
B60017	B3FORA	3	D	.6	399						402			405		
B60018	B2FORA	-1	D	.6	410						413			416		
B60019	B2FORA	1	D	.6	411						414			417		
B60020	B2FORA	3	D	.6	412						415			418		
B60021	BRA	B	0	.4	428	427		426				424				423
B60022	BRA	B	0	.6	429					430		431				
B60023	BRA	B	0	.8	435					434		433				
B60024	BRA	B	0	.9	436			437	438	439			440			
B60025	BRA	B	0	1	445		444	443		442			441			

DATA SET SUMMARY

DISC RDKA02

TEST FACILITY AEDC 4T　TEST DATE MAY 1978　TEST I.D. P41C-11

DATA SET	CONFIGURATION	A	P	M	DATA SET POSITION/CRT											
					1 .01	2 1	3 2.5	4 4	5 6	6 7.2	7 8	8 10	9 12	10 15	11 20	12 37.5
B60026	BRA	B	0	1.1	446		447		448	449						
B60027	BRA	B	0	1.25	453	452	451	450								
B60028	BRO	B	0	.4	458											459
B60029	BRO	B	0	.6	461					460						
B60030	BRO	B	0	.8	462							463				
B60031	BRO	B	0	.9	465								464			
B60032	BRO	B	0	1	466								467			
B60033	BRO	B	0	1.1	469					473			472			
B60034	BRO	B	0	1.25	470			471								
B60035	BFORO	B	0	.4	485											486
B60036	BFORO	B	0	.6	488							487				
B60037	BFORO	B	0	.8	491							492				
B60038	BFORO	B	0	.9	478											
B60039	BFORO	B	0	1	479											
B60040	BFORO	B	0	1.1	482					481						
B60041	BFORO	B	0	1.25	493			494								

SCHEDULES

B = -4, -3, -2, -1, -.5, 0, .5, 1, 2, 3, 4
C = -1, 1, 3
D = 0, 10, 20, 22.5, 30, 45, 67.5, 90, 112.5, 135, 157.5, 180
225, 270, 315

DATA SET SUMMARY　　DISC RDKA02

TEST FACILITY AEDC VKF-A				TEST DATE JUNE 1978			TEST I.D. U41A-U7A				
					DATA SET POSITION/CRT						
					1	2	3	4	5	6	7
DATA SET	CONFIGURATION	A	P	M	.01	1	2	3	4	5	6
D60001	BFORA	A	0	1.75	223	225	226	227	228	229	230
D60002	BFORA	A	0	2.0	216		218		219		220
D60003	BFORA	A	0	2.5	258	260	261	262	263	264	265
D60004	BFORA	A	0	1.75	170	172	173			174	
D60005	BFORO	A	0	3.0	223	234	235	236	237	238	239
D60006	BFORO	A	0	1.75	210		211		212		213
D60007	BFORO	A	0	2.0	268	269	270	271	272	273	274
D60008	BFORO	A	0	2.5	177	178	179			180	
D60009	BRO *	A	0	3.0	242		243	244	245		246
D60010	BRA	A	0	1.75	297		198		199		200
D60011	BRA	A	0	2.0	277	278	279	280	281	282	283
D60012	BRA	A	0	2.5	191	192	193			194	
D60013	BRA *	A	0	3.0	249	250	251	252	253	254	255
D60014	BRO	A	0	1.75	203		204		205		206
D60015	BRO	A	0	2.5	286	287	288			289	
D60016	BRO	A	0	3.0	183	184	185			186	

SCHEDULES　A = -4, -3, -2, -1, -.5, 0, .5, 1, 2, 3, 4, 6

LIST OF SYMBOLS

C, C_{LL}	Rolling-moment coefficient, rolling moment/(q_∞ Sd)
C_D, CD	Drag coefficient, drag/(q_∞ S)
$C_{D\alpha=0}$	Drag coefficient at zero angle of attack
$C_{\ell\alpha=0}$	Rolling-moment coefficient at zero angle of attack
C_m, CLM	Pitching-moment coefficient, pitching moment/(q_∞ Sd)
$C_{m\alpha}$	Pitching-moment coefficient derivative with respect to angle of attack, per degree
C_N, CN	Normal-force coefficient, normal force/(q_α S)
$C_{N\alpha}$	Normal-force coefficient derivative with respect to angle of attack, per degree
C_N, CLN	Yawing-moment coefficient, yawing moment/(q_∞ Sd)
C_y, CY	Side-force coefficient, side force/(q_∞ S)
d	Reference diameter, 2.5 in.
M	Free-stream Mach number
q	Free-stream dynamic pressure, psia
S	Reference area, 4.91 in.^{2}
X_{cp}	Center of pressure, calibers aft of the nose
α	Angle of attack, deg
ϕ	Roll angle, deg

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